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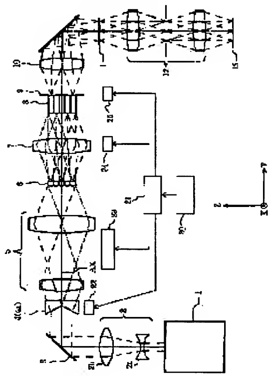
(54) ILLUMINATION OPTICAL DEVICE AND ALIGNER EQUIPPED THEREWITH

(57)Abstract:
PROBLEM TO BE SOLVED: To provide such irregular illumination as annular illumination or 4-pole illumination while suppressing the light loss at an aperture stop well.
SOLUTION: Diagonal optical flux formation means 4 and 5 are provided which convert the optical flux from a light-source means 1 into a light flux, which is incident on a first optical integrator 6 from a diagonal direction almost symmetric about a reference optical axis(AX). As a result, as a second multiple light source formed by a second optical integrator 8, an annular light source or a plurality of light sources decentered from the reference optical axis are formed.



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CLAIMS

[Claim(s)]
[Claim 1] the [for forming the 1st a large number light source which consists of much light sources based on the flux of light from the light source means and this light source means for supplying the flux of light] -- with 1 optical integrator the [this] -- the [for forming the 2nd a large number light source which consists of much light sources more based on the flux of light from the 1st a large number light source formed by 1 optical integrator] -- with 2 optical integrator In illumination-light study equipment equipped with the capacitor optical system for condensing the flux of light from the 2nd a large number light source formed by 2 optical integrator, and illuminating an irradiated plane the [this] -- In order to form two or more light sources which carried out eccentricity from zona-orbicularis-like the light source or a criteria optical axis as said 2nd a large number light source the flux of light from said light source means -- said criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant / said] -- the illumination-light study equipment characterized by arranging the slanting flux of light means forming for changing into 1 optical integrator at the flux of light which carries out incidence.
[Claim 2] The flux of light configuration modification member for changing said slanting flux of light means forming into two or more flux of lights which carried out eccentricity of the flux of light from said light source means to zona-orbicularis-like the flux of light or said criteria optical axis substantially, the flux of light in which a configuration change was made by this flux of light configuration modification member -- said criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant / said] -- in order to carry out incidence in superposition to 1 optical integrator Illumination-light study equipment according to claim 1 characterized by having the condensing optical system which condenses the flux of light in which a configuration change was made by said flux of light configuration modification member.
[Claim 3] Said flux of light configuration modification member is illumination-light study equipment according to claim 2 characterized by having two or more prism member or two or more diffracted-light study components which were constituted free [insertion and detachment] to the illumination-light way.
[Claim 4] Said condensing optical system is illumination-light study equipment according to claim 2 or 3 characterized by having the 1st variable power optical system with a scale factor strange good in order to change the location of each quantity of light center of gravity of two or more light sources formed as the zona-orbicularis ratio of the light source or said 2nd a large number light source of the shape of zona orbicularis formed as said 2nd a large number light source.
[Claim 5] the [said] -- the [1 optical integrator and / said] -- in the optical path between 2 optical integrators The relay optical system for leading to 2 optical integrator is arranged. the [said] -- the flux of light from the 1st a large number light source formed by 1 optical integrator -- condensing -- the [said] -- Said relay optical system is illumination-light study equipment given in claim 1 characterized by having the 2nd variable power optical system with a scale factor strange good in order to change the magnitude of said 2nd a large number light source thru/or any 1 term of 4.
[Claim 6] The aligner characterized by having illumination-light study equipment given in claim 1

thru/or any 1 term of 5, and the projection optics for carrying out projection exposure of the pattern of the mask arranged on said irradiated plane at a photosensitive substrate.
[Claim 7] The exposure approach characterized by exposing the pattern of the mask arranged on said irradiated plane on a photosensitive substrate using illumination-light study equipment given in claim 1 thru/or any 1 term of 5.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the suitable illumination-light study equipment for the aligner for especially manufacturing a semiconductor device etc. at a lithography process about the aligner equipped with illumination-light study equipment and this illumination-light study equipment.
[0002]
[Description of the Prior Art] In this kind of aligner, incidence of the flux of light injected from the light source is carried out to a fly eye lens, and it forms in an after that side focal plane the secondary light source which consists of many light source images. After the flux of light from the secondary light source is restricted through the aperture diaphragm arranged near the backside [a fly eye lens] focal plane, incidence of it is carried out to a condenser lens. An aperture diaphragm restricts to the configuration of the secondary light source, the configuration of a request of magnitude, or magnitude according to desired lighting conditions (exposure conditions).
[0003] The flux of light condensed by the condenser lens illuminates in superposition the mask with which the predetermined pattern was formed. Image formation of the light which penetrated the pattern of a mask is carried out on a wafer through projection optics. In this way, on a wafer, projection exposure (imprint) of the mask pattern is carried out. In addition, it is indispensable to integrate highly the pattern formed in the mask and to imprint this detailed pattern correctly on a wafer to acquire uniform illumination distribution on a wafer.
[0004] In recent years, the technique of changing the magnitude of the secondary light source formed of a fly eye lens, and changing the coherency sigma of lighting (pupil diameter of the diameter of sigma= aperture diaphragm / projection optics) attracts attention by changing the magnitude of opening of the aperture diaphragm arranged at the injection side of a fly eye lens. Moreover, by setting up the configuration of opening of the aperture diaphragm arranged at the injection side of a fly eye lens the shape of zona orbicularis, and in the shape of 4 holes, the configuration of the secondary light source formed of a fly eye lens is restricted the shape of zona orbicularis, and in the shape of 4 holes, and the technique of raising the depth of focus and resolution of projection optics attracts attention.
[0005]
[Problem(s) to be Solved by the Invention] As mentioned above, with the conventional technique, in order to restrict the configuration of the secondary light source the shape of zona orbicularis, and in the shape of 4 holes and to perform deformation lighting (zona-orbicularis deformation lighting and 4 pole deformation lighting), the aperture diaphragm which has opening of the shape of the shape of zona orbicularis or 4 holes has restricted the flux of light from the comparatively big secondary light source formed in the shape of a rectangle of the fly eye lens. If it puts in another way, with the zona-orbicularis deformation lighting or 4 pole deformation lighting in the conventional technique, the considerable part of the flux of light from the secondary light source will be covered by the aperture diaphragm, and will not contribute to lighting (exposure). Consequently, there was un-arranging [that the illuminance on a mask and a wafer fell and the

throughput as an aligner also fell by quantity of light loss in an aperture diaphragm].
[0006] This invention is made in view of the above-mentioned technical problem, and it aims at offering the aligner equipped with the illumination-light study equipment and this illumination-light study equipment which can perform deformation lighting like zona-orbicularis lighting or 4 pole lighting, suppressing the quantity of light loss in an aperture diaphragm good.
[0007]
[Means for Solving the Problem] In order to solve said technical problem, in the 1st invention of this invention the [for forming the 1st a large number light source which consists of much light sources based on the flux of light from the light source means and this light source means for supplying the flux of light] -- with 1 optical integrator the [this] -- the [for forming the 2nd a large number light source which consists of much light sources more based on the flux of light from the 1st a large number light source formed by 1 optical integrator] -- with 2 optical integrator In illumination-light study equipment equipped with the capacitor optical system for condensing the flux of light from the 2nd a large number light source formed by 2 optical integrator, and illuminating an irradiated plane the [this] -- In order to form two or more light sources which carried out eccentricity from zona-orbicularis-like the light source or a criteria optical axis as said 2nd a large number light source the flux of light from said light source means -- said criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant / said] -- the illumination-light study equipment characterized by arranging the slanting flux of light means forming for changing into 1 optical integrator at the flux of light which carries out incidence is offered.
[0008] According to the desirable mode of the 1st invention, said slanting flux of light means forming The flux of light configuration modification member for changing into two or more flux of lights which carried out eccentricity of the flux of light from said light source means to zona-orbicularis-like the flux of light or said criteria optical axis substantially, the flux of light in which a configuration change was made by this flux of light configuration modification member -- said criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant / said] -- in order to carry out incidence in superposition to 1 optical integrator, it has the condensing optical system which condenses the flux of light in which a configuration change was made by said flux of light configuration modification member. In this case, as for said flux of light configuration modification member, it is desirable to have two or more prism member or two or more diffracted-light study components which were constituted free [insertion and detachment] to the illumination-light way.
[0009] Moreover, according to the desirable mode of the 1st invention, said condensing optical system has the 1st variable power optical system with a scale factor strange good, in order to change the location of each quantity of light center of gravity of two or more light sources formed as the zona-orbicularis ratio of the light source or said 2nd a large number light source of the shape of zona orbicularis formed as said 2nd a large number light source. the [furthermore, / said] -- the [1 optical integrator and / said] -- the inside of the optical path between 2 optical integrators -- the [said] -- the flux of light from the 1st a large number light source formed by 1 optical integrator -- condensing -- the [said] -- the relay optical system for leading to 2 optical integrator is arranged, and in order to change the magnitude of said 2nd a large number light source, as for said relay optical system, it is desirable to have the 2nd variable power optical system with a scale factor strange good.
[0010] Moreover, in the 2nd invention of this invention, the aligner characterized by having the illumination-light study equipment of the 1st invention and the projection optics for carrying out projection exposure of the pattern of the mask arranged on said irradiated plane at a photosensitive substrate is offered. Furthermore, in the 3rd invention, the exposure approach characterized by exposing the pattern of the mask arranged on said irradiated plane on a photosensitive substrate using the illumination-light study equipment of the 1st invention is offered.
[0011]
[Embodiment of the Invention] this invention -- the [a light source means and] -- slanting flux of light means forming is arranged in the optical path between 1 optical integrators. this slanting

flux of light means forming -- the flux of light from a light source means -- a criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant] -- it changes into 1 optical integrator at the flux of light which carries out incidence. Specifically, slanting flux of light means forming consists of a flux of light configuration modification member like for example, cone prism or pyramid prism, and condensing optical system like afocal optical system.
[0012] The flux of light from a light source means is changed into two or more flux of lights which carried out eccentricity to zona-orbicularis-like the flux of light or a criteria optical axis substantially through a flux of light configuration modification member. In this case, if cone prism is used as a flux of light configuration modification member, it will be substantially changed into the zona-orbicularis-like flux of light, and it will be changed into two or more flux of lights which carried out eccentricity to the criteria optical axis if pyramid prism is used. In addition, it can replace with cone prism or pyramid prism, and the diffracted-light study component which has an operation equivalent to this can also be used.
[0013] the flux of light in which a configuration change was made by the flux of light configuration modification member condenses through condensing optical system -- having -- a criteria optical axis -- receiving -- almost -- the symmetry -- the [from slant] -- incidence is carried out in superposition to 1 optical integrator. the [in this way,] -- the 1st a large number light source is formed by 1 optical integrator. the flux of light from the 1st a large number light source condenses through relay optical system -- having -- the -- it is led to 2 optical integrator. the [consequently,] -- two or more light sources which carried out eccentricity from zona-orbicularis-like the light source or a criteria optical axis can be formed as the 2nd a large number light source by 2 optical integrator, i.e., the secondary light source.
[0014] Here, if cone prism is used as a flux of light configuration modification member, the zona-orbicularis-like light source will be formed, and if pyramid prism is used, two or more light sources which carried out eccentricity from the criteria optical axis will be formed. If 4 pyramid prism (only henceforth "pyramid prism") is especially used as pyramid prism, the secondary light source which consists of the four light sources which carried out eccentricity symmetrically from the criteria optical axis, i.e., the secondary 4 pole-like light source, will be formed. the [thus,] -- the flux of light from the secondary light source of the shape of the shape of zona orbicularis formed by 2 optical integrator and 4 poles illuminates an irradiated plane, after being restricted by the aperture diaphragm which has opening according to the magnitude and the configuration of the secondary light source.
[0015] Thus, in this invention, the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be formed, without almost carrying out quantity of light loss based on the flux of light from a light source means. Consequently, zona-orbicularis deformation lighting and 4 pole deformation lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the flux of light from the secondary light source good. In addition, it cannot be overemphasized that the usual circular lighting can be performed, suppressing quantity of light loss good by evacuating slanting flux of light means forming from an illumination-light way.
[0016] Moreover, in this invention, the location of each quantity of light center of gravity of two or more light sources formed as the zona-orbicularis ratio of the light source or the 2nd a large number light source of the shape of zona orbicularis formed as the 2nd a large number light source can be changed by a scale factor's constituting condensing optical system as adjustable variable power optical system, and changing the scale factor of this variable power optical system. the [furthermore,] -- the [1 optical integrator and] -- the magnitude of the 2nd a large number light source can be changed by a scale factor's constituting the relay optical system arranged in the optical path between 2 optical integrators as adjustable variable power optical system, and changing the scale factor of this variable power optical system.
[0017] As mentioned above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the secondary light source good. In addition, the parameter (the magnitude and the configuration of the secondary light source which were restricted) of

deformation lighting can be changed by easy variable power actuation, suppressing the quantity of light loss by the aperture diaphragm good. Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure approach which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good semiconductor device can be manufactured.

[0018] The example of this invention is explained based on an accompanying drawing. Drawing 1 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 1st example of this invention. In drawing 1 , the X-axis is set [the Z-axis] up in the direction perpendicular to the space of drawing 1 for the Y-axis in a wafer side in the direction parallel to the space of drawing 1 in a wafer side along the direction of a normal of the wafer 13 which is a photosensitive substrate, respectively.

[0019] The aligner of drawing 1 is equipped with the excimer laser which supplies wavelength (248nm or 193nm) of light as the light source 1 for supplying exposure light (illumination light). The almost parallel flux of light injected along with the Z direction from the light source 1 has the cross section of the shape of a rectangle prolonged long and slender along the direction of X, and it carries out incidence to the beam expander 2 which consists of cylindrical-lens 2a of a pair, and 2b. Each cylindrical-lens 2a and 2b have negative refractive power and forward refractive power in the space of drawing 1 (inside of YZ flat surface), respectively, and function as a plane-parallel plate in the field which intersects perpendicularly with space including an optical axis AX (inside of XZ flat surface). Therefore, the flux of light which carried out incidence to the beam expander 2 is expanded in the space of drawing 1 , and is orthopedically operated by the flux of light which has the cross section of a predetermined configuration, for example, the flux of light which has a square-like cross section.

[0020] After the flux of light through the beam expander 2 as plastic surgery optical system is deflected in the direction of Y by the bending mirror 3, incidence of it is carried out to the cone prism 4. The field by the side of the mask of the cone prism 4 (field by the side of drawing Nakamigi) is formed in the plane perpendicular to an optical axis AX. Moreover, the field by the side of the light source of the cone prism 4 (field of the left-hand side in drawing) is formed in the shape of a cone concave surface toward the light source side. Furthermore, the refracting interface by the side of the light source of the cone prism 4 is equivalent to the detail about the optical axis AX at the conical surface (side face except a base) of a symmetrical cone. Therefore, after the flux of light which carried out incidence to the cone prism 4 is deflected along all directions with equiangular centering on an optical axis AX, incidence of it is carried out to the afocal zoom lens 5. Thus, the cone prism 4 constitutes the flux of light configuration modification member for changing substantially the flux of light from a light source means into the zona-orbicularis-like flux of light.

[0021] In addition, although the cone concave surface of the cone prism 4 has turned to the light source side in drawing 1 , the cone prism 4 may be arranged so that a cone concave surface may turn to a mask side. Moreover, to the illumination-light way, it is constituted free [insertion and detachment], and the cone prism 4 is constituted possible [pyramid prism 4a as other flux of light configuration modification members, and a switch]. About the configuration and operation of pyramid prism 4a, it mentions later. Moreover, maintaining an afocal system (non-focal optical system), the afocal zoom lens 5 is constituted so that a scale factor can be continuously changed in the predetermined range. Here, evacuation from a switch and illumination-light way of the cone prism 4 and pyramid prism 4a is performed by the flux of light configuration modification member drive system 22 which operates based on the command from a control system 21. Moreover, scale-factor change of the afocal zoom lens 5 is performed by the variable power drive system 23 which operates based on the command from a control

system 21.
[0022] The flux of light which carried out incidence to the afocal zoom lens 5 forms a ring-like (in a circle) light source image in the pupil surface. the light from a ring-like light source image serves as the almost parallel flux of light, and is injected from the afocal zoom lens 5 -- having -- the -- incidence is carried out to the 1st fly eye lens 6 as a 1 optical integrator. At this time, the flux of light carries out incidence to the symmetry from across mostly to an optical axis AX at the plane of incidence of the 1st fly eye lens 6. If it puts in another way, the flux of light will carry out oblique incidence along all directions with equiangular a core [an optical axis AX]. The 1st fly eye lens 6 is constituted when a cross section carries out the in-every-direction array of the lens element of a large number which have refractive power forward by the shape of a square in accordance with an optical axis AX. In addition, the field by the side of the incidence of each lens element is formed in the shape of [which turned the convex to the incidence side] the spherical surface, and the field by the side of injection is formed in the plane.
[0023] Therefore, the flux of light which carried out incidence to the 1st fly eye lens 6 is divided by many lens elements two-dimensional, and the light source image of the shape of one ring is formed in a backside [each lens element] focal plane, respectively. the [after the flux of light from the ring-like light source image of a large number formed in the backside / the 1st fly eye lens 6 / focal plane minds a zoom lens 7] -- the 2nd fly eye lens 8 as a 2 optical integrator is illuminated in superposition. In addition, a zoom lens 7 is the relay optical system to which a focal distance can be continuously changed in the predetermined range, and has connected optically the backside [the 1st fly eye lens 6] focal plane, and the backside [the 2nd fly eye lens 8] focal plane to conjugate mostly. moreover, the zoom lens 7 -- the backside -- a tele cent -- rucksack optical system is constituted. In order to satisfy above-mentioned conjugation relation and telecentricity, as for the zoom lens 7, at least three lens groups are constituted as an independently movable multi-group zoom lens. Focal distance change of a zoom lens 7 is performed by the variable power drive system 24 which operates based on the command from a control system 21.
[0024] Therefore, the radiation field of the configuration where only the number of infinity has arranged the radiation field of the shape of a square [**** / the cross-section configuration of each lens element of the 1st fly eye lens 6] in the location of an optical axis AX to the equal distance, i.e., the radiation field of the shape of zona orbicularis centering on an optical axis AX, is formed in the plane of incidence of the 2nd fly eye lens 8. The 2nd fly eye lens 8 is constituted by carrying out the in-every-direction array of the lens element of a large number which have forward refractive power in accordance with an optical axis AX like the 1st fly eye lens 6. However, each lens element which constitutes the 2nd fly eye lens 8 has the cross section of the shape of a rectangle [**** / the configuration (as a result, configuration of the exposure field which should be formed on a wafer) of the radiation field which should be formed on a mask]. Moreover, the field by the side of the incidence of each lens element which constitutes the 2nd fly eye lens 8 is formed in the shape of [which turned the convex to the incidence side] the spherical surface, and the field by the side of injection is formed in the shape of [which turned the convex to the injection side] the spherical surface.
[0025] Therefore, the flux of light which carried out incidence to the 2nd fly eye lens 8 is divided by many lens elements two-dimensional, and many light source images of the number of the lens elements of the 1st fly eye lens 6 are formed in a backside [each lens element in which the flux of light carried out incidence] focal plane, respectively. In this way, the a large number light source (henceforth the "secondary light source") of the shape of same zona orbicularis as the radiation field formed of the incoming beams to the 2nd fly eye lens 8 is formed in a backside [the 2nd fly eye lens 8] focal plane. Incidence of the flux of light from the secondary light source of the shape of zona orbicularis formed in the backside [the 2nd fly eye lens 8] focal plane is carried out to the aperture diaphragm 9 arranged in the near. This aperture diaphragm 9 is supported on the turret (rotor plate : drawing 1 un-illustrating) pivotable to the circumference of a predetermined axis parallel to an optical axis AX.
[0026] Drawing 2 is drawing showing roughly the configuration of the turret by which two or more aperture diaphragms have been arranged in the shape of a periphery. As shown in drawing 2 ,

eight aperture diaphragms which have the light transmission region shown in the turret substrate 400 with the slash in drawing are prepared along with the circumferencial direction. The turret substrate 400 is constituted pivotable through the central point O at the circumference of an axis parallel to an optical axis AX. Therefore, one aperture diaphragm chosen from eight aperture diaphragms can be positioned all over an illumination-light way by rotating the turret substrate 400. In addition, rotation of the turret substrate 400 is performed by the turret drive system 25 which operates based on the command from a control system 21.
[0027] Three zona-orbicularis aperture diaphragms 401, 403, and 405 from which a zona-orbicularis ratio differs are formed in the turret substrate 400. Here, the zona-orbicularis aperture diaphragm 401 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r11/r21. The zona-orbicularis aperture diaphragm 403 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r12/r22. The zona-orbicularis aperture diaphragm 405 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r13/r21.
[0028] Moreover, three 4 pole aperture diaphragms 402, 404, and 406 from which a zona-orbicularis ratio differs are formed in the turret substrate 400. Here, 4 pole aperture diaphragm 402 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r11/r21. 4 pole aperture diaphragm 404 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r12/r22. 4 pole aperture diaphragm 406 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r13/r21. Furthermore, two circular aperture diaphragms 407 and 408 from which magnitude (aperture) differs are formed in the turret substrate 400. Here, the circular aperture diaphragm 407 has the circular transparency field of the magnitude of two r22, and the circular aperture diaphragm 408 has the circular transparency field of the magnitude of two r21.
[0029] Therefore, by choosing zona-orbicularis 1 of three zona-orbicularis aperture diaphragms 401, 403, and 405, and positioning in an illumination-light way, the zona-orbicularis flux of light which has three different zona-orbicularis ratios can be restricted correctly (convention), and three kinds of zona-orbicularis deformation lighting with which zona-orbicularis ratios differ can be performed. Moreover, by choosing 4 pole 1 of three 4 pole aperture diaphragms 402, 404, and 406, and positioning in an illumination-light way, the four eccentric flux of lights which have three different zona-orbicularis ratios can be restricted correctly, and three kinds of 4 pole deformation lighting with which zona-orbicularis ratios differ can be performed. Furthermore, two kinds of usual circular lighting with which sigma values differ can be performed by choosing circular 1 of two circular aperture diaphragms 407 and 408, and positioning in an illumination-light way.
[0030] In drawing 1 , since the secondary zona-orbicularis-like light source is formed in a backside [the 2nd fly eye lens 8] focal plane, one zona-orbicularis aperture diaphragm chosen from three zona-orbicularis aperture diaphragms 401, 403, and 405 as an aperture diaphragm 9 is used. However, the class and number of aperture diaphragms which are instantiation-like [the configuration of a turret shown in drawing 2], and are arranged are not limited to this. Moreover, the possible aperture diaphragm of changing light transmission area size and a configuration suitably may be attached fixed in an illumination-light way, without being limited to the aperture diaphragm of a turret method.
[0031] The light from the secondary light source through the aperture diaphragm 9 which has zona-orbicularis-like opening (light transmission section) carries out homogeneity lighting of the mask 11 with which the predetermined pattern was formed in superposition, after receiving a condensing operation of the capacitor optical system 10. The flux of light which penetrated the pattern of a mask 11 forms the image of a mask pattern through projection optics 12 on the wafer 13 which is a photosensitive substrate. In this way, the pattern of a mask 11 is serially exposed by each exposure field of a wafer 13 by performing one-shot exposure or scanning exposure, carrying out drive control of the wafer 13 two-dimensional into the flat surface (XY flat surface) which intersects perpendicularly with the optical axis AX of projection optics 12.
[0032] In addition, in one-shot exposure, a mask pattern is exposed in package to each exposure

field of a wafer according to the so-called step-and-repeat method. the shape of in this case, a rectangle with the configuration of the lighting field on a mask 11 near a square -- it is -- the -- the cross-section configuration of each lens element of 2 optical integrator also turns into the shape of a rectangle near a square. On the other hand, in scanning exposure, scanning exposure of the mask pattern is carried out to each exposure field of a wafer according to so-called step - and - scanning method, making a mask and a wafer displaced relatively to projection optics. in this case, the configuration of the lighting field on a mask 11 -- the ratio of a shorter side and a long side -- the shape of for example, a rectangle of 1:3 -- it is -- the -- the cross-section configuration of each lens element of 2 optical integrator also turns into the shape of a rectangle [**** / this].

[0033] Drawing 3 is drawing showing roughly the configuration from the cone prism 4 to the plane of incidence of the 1st fly eye lens 6, and is drawing explaining an operation of the afocal zoom lens 5. As shown in drawing 3 (a), after the flux of light deflected [by the cone prism 4] along all directions with equiangular [of an include angle alpha] centering on the optical axis AX minds the afocal zoom lens 5 of a scale factor m1, oblique incidence of it is carried out to the plane of incidence of the 1st fly eye lens 6 along all directions with equiangular [of an include angle theta 1] a core [an optical axis AX]. The magnitude of the radiation field formed in the plane of incidence of the 1st fly eye lens 6 at this time is d1. If the scale factor of the afocal zoom lens 5 is changed to m2 from m1 as shown in drawing 3 (b), here The flux of light deflected [by the cone prism 4] along all directions with equiangular [of an include angle alpha] centering on the optical axis AX After minding the afocal zoom lens 5 of a scale factor m2, oblique incidence is carried out to the plane of incidence of the 1st fly eye lens 6 along all directions with equiangular [of an include angle theta 2] a core [an optical axis AX]. The magnitude of the radiation field formed in the plane of incidence of the 1st fly eye lens 6 at this time is d2.

[0034] Here, between the magnitude d1 and d2 of the radiation field formed in theta1 and theta2, and a list at the plane of incidence of the 1st fly eye lens 6 whenever [incident angle / of the flux of light to the plane of incidence of the 1st fly eye lens 6], and the scale factors m1 and m2 of the afocal zoom lens 5, the relation shown in the following formula (1) and (2) is materialized.

theta2= (m1/m2), theta 1 (1)

d2= (m2/m1), d1 (2)

When a formula (1) is referred to, by changing continuously the scale factor m of the afocal zoom lens 5 shows that theta can be changed continuously whenever [incident angle / of the flux of light to the plane of incidence of the 1st fly eye lens 6].

[0035] Drawing 4 is drawing showing roughly the configuration from the 1st fly eye lens 6 to an aperture diaphragm 9, and is drawing showing signs that the flux of light which carried out oblique incidence to the plane of incidence of the 1st fly eye lens 6 forms a zona-orbicularis-like radiation field in the plane of incidence of the 2nd fly eye lens 8. As a continuous line shows drawing 4 (a), the flux of light which carried out oblique incidence from the predetermined direction at an angle of predetermined to the plane of incidence of the 1st fly eye lens 6 forms the radiation field which has predetermined width of face in the location which carried out oblique incidence to the zoom lens 7, and carried out eccentricity only of the predetermined distance from the optical axis AX in the plane of incidence of the 2nd fly eye lens 8 to it, holding an include angle, even after carrying out image formation through each lens element.

[0036] In fact, as a broken line shows drawing 4 (a), the flux of light carries out incidence to the symmetry from across mostly to an optical axis AX at the plane of incidence of the 1st fly eye lens 6. If it puts in another way, the flux of light will carry out oblique incidence along all directions with equiangular a core [an optical axis AX]. Therefore, as shown in drawing 4 (b), the radiation field of the shape of zona orbicularis centering on an optical axis AX will be formed in the plane of incidence of the 2nd fly eye lens 8. Moreover, the secondary light source of the shape of same zona orbicularis as the radiation field formed in plane of incidence will be formed in a backside [the 2nd fly eye lens 8] focal plane. On the other hand, as mentioned above, opening (part of void among drawing 4 (c)) of the shape of zona orbicularis corresponding to the secondary zona-orbicularis-like light source is formed in the zona-orbicularis aperture diaphragm

9 arranged near the backside [the 2nd fly eye lens 8] focal plane. In this way, when using the cone prism 4 as a flux of light configuration modification member, the secondary zona-orbicularis-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and zona-orbicularis deformation lighting can be performed, without almost carrying out quantity of light loss in the aperture diaphragm 9 which, as a result, restricts the flux of light from the secondary light source.

[0037] Drawing 5 is drawing showing roughly the configuration from the cone prism 4 to the plane of incidence of the 2nd fly eye lens 8, and is drawing explaining the scale factor of the afocal zoom lens 5 and the focal distance of a zoom lens 7, the magnitude of the radiation field of the shape of zona orbicularis formed in the plane of incidence of the 2nd fly eye lens 8, and relation with a configuration. In drawing 5 , after the main beam of light of the flux of light injected at the include angle alpha centering on the optical axis AX from the cone prism 4 minds the afocal zoom lens 5 of a scale factor m, incidence of it is carried out to the 1st fly eye lens 6 at an include angle theta to an optical axis AX. As for the 1st fly eye lens 6, the focal distance is constituted for size from the lens element of f1 by a. The main beam of light injected at the include angle theta reaches the plane of incidence of the 2nd fly eye lens 8 through the zoom lens 7 of a focal distance fr from the lens element of the 1st fly eye lens 6. At this time, the incidence range of the flux of light in the plane of incidence of the 2nd fly eye lens 8 turns into range which has width of face b focusing on the height of y from an optical axis AX. That is, as shown in drawing 4 (b), the radiation field formed in the plane of incidence of the 2nd fly eye lens 8, as a result the secondary light source formed in a backside [the 2nd fly eye lens 8] focal plane will have height y from an optical axis AX, and will have width of face b.

[0038] Here, between theta, the relation shown by the following formula (3) is materialized [whenever / incident angle / to alpha and the 1st fly eye lens 6] whenever [from the cone prism 4 / angle-of-emergence].

theta=(1/m) -alpha (3)

Moreover, height [of the secondary zona-orbicularis-like light source] y and its width of face b are expressed with the following formula (4) and (5), respectively.

y=fr and sintheta (4)

b=(fr/f1) -a (5)

[0039] Therefore, bore phii of the secondary zona-orbicularis-like light source Outer-diameter phio The zona-orbicularis ratio A specified by the ratio is expressed with the following formula (6).

[Equation 1]

A=phi i/phio =(2 y-b)/(2 y+b) = {2f1 and sin(alpha/m)-a} /{2f1 and sin(alpha/m)+a} (6)

Moreover, outer-diameter phio of the secondary zona-orbicularis-like light source It is expressed with the following formula (7).

phio =2 y+b=fr {2 sin(alpha/m)+a/f1} (7)

[0040] Deformation of a formula (7) obtains the relation shown in the following formula (8).

Fr=phi o/{2 sin(alpha/m)+a/f1} (8)

In this way, when the scale factor m of the afocal zoom lens 5 changes without the focal distance fr of a zoom lens 7 changing if a formula (3) and (4) are referred to, it turns out that only the height y changes, without the width of face b of the secondary zona-orbicularis-like light source changing. That is, the magnitude (outer-diameter phio) and its configuration (zona-orbicularis ratio A) can be changed [both] by changing the scale factor m of the afocal zoom lens 5, without changing the width of face b of the secondary zona-orbicularis-like light source.

[0041] Moreover, when only the focal distance fr of a zoom lens 7 changes without the scale factor m of the afocal zoom lens 5 changing if a formula (4) and (5) are referred to, it turns out that the width of face b of the secondary zona-orbicularis-like light source and its height y change in proportion to both the focal distances fr. That is, only the magnitude (outer-diameter phio) can be changed by changing only the focal distance fr of a zoom lens 7, without changing the configuration (zona-orbicularis ratio A) of the secondary zona-orbicularis-like light source. Furthermore, if a formula (6) and (8) are referred to, it is outer-diameter phio of fixed magnitude. It turns out that only the configuration (zona-orbicularis ratio A) can be changed, without

changing the magnitude (outer-diameter phio) of the secondary zona-orbicularis-like light source by changing the scale factor m of the afocal zoom lens 5, and the focal distance fr of a zoom lens 7 so that it may receive and the relation of a formula (8) may be filled.
[0042] Hereafter, according to a concrete numerical example, change with the scale factor m of the afocal zoom lens 5 in the case of changing only the configuration (zona-orbicularis ratio A) and the focal distance fr of a zoom lens 7 is explained, without changing the magnitude (outer-diameter phio) of the secondary zona-orbicularis-like light source. In this example of the 1st numeric value, the deflecting angle alpha by the cone prism 4 is made into 7 times, size a of each lens element of the 1st fly eye lens 6 is set to 2.5mm, and the focal distance f1 of each lens element is set to 50mm. And outer-diameter phio of the secondary zona-orbicularis-like light source The scale factor m of the afocal zoom lens 5 required to change the zona-orbicularis ratio A to about 0.24 - abbreviation 0.95 and the focal distance fr of a zoom lens 7 are found, respectively, holding uniformly by 96mm. The correspondence relation between the scale factor m of the afocal zoom lens 5, and the zona-orbicularis ratio A of the secondary zona-orbicularis-like light source and the focal distance fr of a zoom lens 7 in the example of the 1st numeric value is shown in the next table (1).
[0043]
[Table 1]
alpha= 7 times a=2.5mmf1=50mmphio =96mmm A fr0.1 0.94817 49.756780.2 0.916468 80.190260.3 0.881258 113.99270.4 0.846487 147.37230.5 0.812679 179.82790.6 0.779947 211.25130.7 0.748299 241.63320.8 0.717711 270.99750.9 0.688146 299.38011.0 0.659561 326.82111.1 0.631915353.36161.2 0.605165 379.04191.3 0.57927403.9011.4 0.554191 427.97631.5 0.529893 451.30311.6 0.506338 473.91511.7 0.483496 495.84391.8 0.461334 517.11981.9 0.439822 537.77112.00.418933 557.82472.1 0.39864 577.30592.2 0.378918 596.23872.3 0.359744614.64592.4 0.341095 632.5492.5 0.32295649.96822.60. 305289 666.92282.7 0.288092 683.43132.8 0.271343 699.51082.9 0.255023 715.17783.00.239117 730.448 [0044] When a table (1) is referred to, in order to change the zona-orbicularis ratio A from about 0.5 to about 0.69, while changing the scale factor m of the afocal zoom lens 5 from about 0.9 to about 1.6, in the example of the 1st numeric value, it turns out that what is necessary is just to carry out the focal distance fr of a zoom lens 7 from about 474mm to about 300mm. As mentioned above, to the illumination-light way, it is constituted free [insertion and detachment], and the cone prism 4 is constituted possible [pyramid prism 4a and a switch]. When it replaces with the cone prism 4 and pyramid prism 4a is hereafter set up all over an illumination-light way, the case where the cone prism 4 is evacuated from an illumination-light way is explained.
[0045] In pyramid prism 4a, the field by the side of a mask is formed in the plane perpendicular to an optical axis AX. Moreover, the field by the side of the light source of pyramid prism 4a consists of four refracting interfaces, and, on the whole, is formed in the shape of a pyramid concave surface toward the light source side. Furthermore, four refracting interfaces are equivalent to the detail at the pyramidal surface (side face except a base) of the forward square drill which carries out the top-most vertices of one on an optical axis AX, and has four ridgelines along with the X-axis and the Z-axis. That is, four refracting interfaces are equivalent to the pyramidal surface of a symmetrical forward square drill about the optical axis AX. In addition, like the case of the cone prism 4, pyramid prism 4a may be arranged so that a pyramid concave surface may turn to a mask side.
[0046] Therefore, when it replaces with the cone prism 4 based on the command of a control system 21 according to an operation of the flux of light configuration modification member drive system 22 and pyramid prism 4a is positioned all over an illumination-light way, after the flux of light which carried out incidence to pyramid prism 4a is deflected along four equiangular and specific directions centering on an optical axis AX, incidence of it is carried out to the afocal zoom lens 5. Thus, pyramid prism 4a constitutes the flux of light configuration modification member for changing into the four flux of lights which carried out eccentricity of the flux of light from the light source 1 to the optical axis AX. The flux of light which carried out incidence to the afocal zoom lens 5 forms four punctiform light source images in the pupil surface. In this case, the square to which four punctiform light source images are connected turns into a square which

has the side parallel to the X-axis and the Z-axis centering on an optical axis AX. The light from four punctiform light source images serves as the almost parallel flux of light, is injected from the afocal zoom lens 5, and carries out incidence to the 1st fly eye lens 6. Here, the flux of light carries out incidence to the symmetry from across mostly to an optical axis AX at the plane of incidence of the 1st fly eye lens 6. Furthermore, the flux of light carries out oblique incidence to a detail along four equiangular and specific directions a core [an optical axis AX].
[0047] Therefore, four punctiform light source images are formed in a backside [each lens element of the 1st fly eye lens 6] focal plane, respectively. The flux of light from the punctiform light source image of a large number formed in the backside [the 1st fly eye lens 6] focal plane illuminates the 2nd fly eye lens 8 in superposition, after minding a zoom lens 7. Therefore, four radiation fields to which only the equal distance carried out eccentricity (parallel displacement) of the radiation field of the shape of a square [**** / the cross-section configuration of each lens element of the 1st fly eye lens 6] along the four symmetry radiation directions from the optical axis AX, i.e., the radiation field of the shape of 4 poles centering on an optical axis AX, are formed in the plane of incidence of the 2nd fly eye lens 8. Consequently, as shown in drawing 6 (a), the secondary light source (part shown with the slash in drawing 6 (a)) of the shape of same 4 poles as the radiation field formed in plane of incidence is formed also in a backside [the 2nd fly eye lens 8] focal plane.
[0048] In addition, corresponding to the switch to pyramid prism 4a from the cone prism 4, the switch to aperture-diaphragm 9a from the zona-orbicularis aperture diaphragm 9 is performed. Aperture-diaphragm 9a is one 4 pole aperture diaphragm chosen from three 4 pole aperture diaphragms 402, 404, and 406. As shown in drawing 6 (b), four circular openings (part shown by void among drawing 6 (b)) which have magnitude which is mostly inscribed in the light source of the four shape of a square which constitutes the secondary 4 pole-like light source are formed in 4 pole aperture-diaphragm 9a. Moreover, 4 pole aperture diaphragm which has 1/4 yen-like four openings (part shown by void among drawing 6 (c)) as shown in drawing 6 (c) as aperture-diaphragm 9a can also be used. Thus, also when using pyramid prism 4a as a flux of light configuration modification member, the secondary 4 pole-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and 4 pole deformation lighting can be performed, suppressing the quantity of light loss in aperture-diaphragm 9a which, as a result, restricts the flux of light from the secondary light source good.
[0049] And the location of the quantity of light center of gravity of the light source of the four shape of a square which constitutes the secondary 4 pole-like light source can be changed by changing the scale factor m of the afocal zoom lens 5. If it puts in another way, the magnitude and its configuration can be changed [both], without changing the width of face of the secondary 4 pole-like light source. Here, as a broken line shows drawing 6 (a), 4 pole-like the magnitude and the configuration of the secondary light source can be similarly defined as the secondary zona-orbicularis-like light source. That is, four circles inscribed in the light source of the four shape of a square which constitutes the secondary 4 pole-like light source are assumed. And diameter phii of the small circle which four circles circumscribe Diameter phio of the great circle in which four circles are inscribed Ratio phii/phio It is based, specifies, 4 pole-like a configuration, i.e., a zona-orbicularis ratio, of the secondary light source, and is diameter phio of a great circle. It can be based and the magnitude of the secondary 4 pole-like light source can be specified. In this case, the width of face b of the secondary 4 pole-like light source is diameter phio of a great circle. Diameter phii of a small circle It is specified as 1/2 of a difference. Moreover, only the magnitude can be changed by changing only the focal distance fr of a zoom lens 7, without changing the configuration (zona-orbicularis ratio) of the secondary 4 pole-like light source. Furthermore, only the configuration can be changed, without changing the magnitude of the secondary 4 pole-like light source by changing the scale factor m of the afocal zoom lens 5, and the focal distance fr of a zoom lens 7 so that predetermined relation may be filled.
[0050] On the other hand, when the cone prism 4 is evacuated from an illumination-light way, the flux of light which has a square-like cross section in accordance with an optical axis AX carries out incidence to the afocal zoom lens 5. It is expanded or reduced according to the scale

factor, and the flux of light which carried out incidence to the afocal zoom lens 5 is injected from the afocal zoom lens 5 in accordance with an optical axis AX with the flux of light which has a square-like cross section, and carries out incidence to the 1st fly eye lens 6. Therefore, one punctiform light source image is formed in a backside [each lens element of the 1st fly eye lens 6] focal plane, respectively. Moreover, the radiation field of the shape of a square [**** / the cross-section configuration of each lens element of the 1st fly eye lens 6] is formed in the plane of incidence of the 2nd fly eye lens 8 considering an optical axis AX as a core. Consequently, the secondary light source of the shape of a square centering on an optical axis AX is formed also in a backside [the 2nd fly eye lens 8] focal plane.
[0051] In addition, corresponding to evacuation from the illumination-light way of the cone prism 4, the switch to circular aperture-diaphragm 9b from the zona-orbicularis aperture diaphragm 9 is performed. Circular aperture-diaphragm 9b is one circular aperture diaphragm chosen from two circular aperture diaphragms 407 and 408, and has opening of magnitude which is mostly inscribed in the secondary square-like light source. Thus, by evacuating the cone prism 4 from an illumination-light way, the secondary square-like light source is formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and circular lighting can usually be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the flux of light from the secondary light source good. In this case, the magnitude of the secondary square-like light source can be suitably changed by changing the scale factor m of the afocal zoom lens 5, or the focal distance fr of a zoom lens 7.
[0052] Hereafter, switch actuation of the flux of light configuration modification member in the 1st example and an aperture diaphragm etc. is explained concretely. First, the information about various kinds of masks which should carry out sequential exposure according to step-and-repeat method or step - and - scanning method etc. is inputted into a control system 21 through the input means 20, such as a keyboard. The control system 21 has memorized information, such as optimal line breadth (resolution) about various kinds of masks, and the depth of focus, in the internal memory section, answers an input from the input means 20, and supplies the suitable control signal for the flux of light configuration modification member drive system 22, the variable power drive system 23, the variable power drive system 24, and the turret drive system 25.
[0053] That is, when carrying out zona-orbicularis deformation lighting under the optimal resolution and the depth of focus, the flux of light configuration modification member drive system 22 positions the cone prism 4 all over an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the shape of zona orbicularis which has desired magnitude and a desired zona-orbicularis ratio in a backside [the 2nd fly eye lens 8] focal plane, the variable power drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, and the variable power drive system 24 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary zona-orbicularis-like light source, the turret drive system 25 rotates a turret based on the command from a control system 21, and positions a desired zona-orbicularis aperture diaphragm all over an illumination-light way. In this way, the secondary zona-orbicularis-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and zona-orbicularis deformation lighting can be performed, without almost carrying out quantity of light loss in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.
[0054] Furthermore, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source which are formed in a backside [the 2nd fly eye lens 8] focal plane can be suitably changed if needed by changing the scale factor of the afocal zoom lens 5 by the variable power drive system 23, or changing the focal distance of a zoom lens 7 by the variable power drive system 24. In this case, a turret rotates according to change of the magnitude of the secondary zona-orbicularis-like light source, and a zona-orbicularis ratio, the zona-orbicularis aperture diaphragm which has desired magnitude and a desired zona-orbicularis ratio is chosen, and it is positioned all over an illumination-light way. In this way, without almost carrying out quantity of light loss in formation and its limit of the shape of zona orbicularis of the secondary

light source, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source can be changed suitably, and various zona-orbicularis deformation lighting can be performed.
[0055] Moreover, when carrying out 4 pole deformation lighting under the optimal resolution and the depth of focus, the flux of light configuration modification member drive system 22 positions pyramid prism 4a all over an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the shape of 4 poles which has desired magnitude and a desired configuration (zona-orbicularis ratio) in a backside [the 2nd fly eye lens 8] focal plane, the variable power drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, and the variable power drive system 24 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary 4 pole-like light source, the turret drive system 25 rotates a turret based on the command from a control system 21, and positions desired 4 pole aperture diaphragm all over an illumination-light way. In this way, the secondary 4 pole-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and 4 pole deformation lighting can be performed, suppressing quantity of light loss good in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.
[0056] Furthermore, 4 pole-like the magnitude and the configuration of the secondary light source which are formed in a backside [the 2nd fly eye lens 8] focal plane can be suitably changed if needed by changing the scale factor of the afocal zoom lens 5 by the variable power drive system 23, or changing the focal distance of a zoom lens 7 by the variable power drive system 24. In this case, a turret rotates according to change of the magnitude of the secondary 4 pole-like light source, and a configuration, 4 pole aperture diaphragm which has desired magnitude and a desired configuration is chosen, and it is positioned all over an illumination-light way. In this way, where quantity of light loss is suppressed good in formation and its limit of the shape of 4 poles of the secondary light source, 4 pole-like the magnitude and the configuration of the secondary light source can be changed suitably, and various 4 pole deformation lighting can be performed.
[0057] Furthermore, when carrying out the circular lighting usual by the basis of the optimal resolution and the depth of focus, the flux of light configuration modification member drive system 22 evacuates the cone prism 4 or pyramid prism 4a from an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the shape of a square which has desired magnitude in a backside [the 2nd fly eye lens 8] focal plane, the variable power drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, or the variable power drive system 24 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary square-like light source, the turret drive system 25 rotates a turret based on the command from a control system 21, and positions a desired circular aperture diaphragm all over an illumination-light way. In this way, circular lighting can usually be performed, suppressing quantity of light loss good in the aperture diaphragm which restricts the flux of light from the formed secondary light source without almost carrying out quantity of light loss based on the flux of light from the light source 1.
[0058] Furthermore, the magnitude of the secondary light source of the shape of a square formed in a backside [the 2nd fly eye lens 8] focal plane can be suitably changed if needed by changing the scale factor of the afocal zoom lens 5 by the variable power drive system 23, or changing the focal distance of a zoom lens 7 by the variable power drive system 24. In this case, a turret rotates according to change of the magnitude of the secondary square-like light source, the circular aperture diaphragm which has opening of desired magnitude is chosen, and it is positioned all over an illumination-light way. In this way, suppressing quantity of light loss good in formation and its limit of the shape of a square of the secondary light source, a sigma value can be changed suitably and various usual circular lighting can be performed.
[0059] Drawing 7 is drawing showing roughly the configuration of the aligner equipped with the

illumination-light study equipment concerning the 2nd example of this invention. Moreover, drawing 8 and drawing 9 are drawings which explain concretely an operation of the diffracted-light study component in the 2nd example. However, in drawing (drawing 7 , drawing 11 , and drawing 12) about the following examples and modifications, illustration of the turret drive system 25 (it does not exist in drawing 12) is omitted in the input means 20, a control system 21, the flux of light configuration modification member drive system 22, the variable power drive systems 23 and 24, and a list. The 2nd example has a configuration similar to the 1st example. However, although cone prism and pyramid prism are used as a flux of light configuration modification member in the 1st example, it is only fundamentally different in the 2nd example to use the diffracted-light study component as a flux of light configuration modification member. Therefore, in drawing 7 , the same reference mark as drawing 1 is given to the component of the 1st example, and the element which has the same function. Hereafter, the 2nd example is explained paying attention to difference with the 1st example.

[0060] In the 2nd example, after the flux of light through the beam expander 2 as plastic surgery optical system is deflected in the direction of Y by the bending mirror 3, incidence of it is carried out to diffracted-light study component 4b. Diffracted-light study component 4b is constituted by forming the level difference which has the pitch of wavelength extent of exposure light (illumination light) in a glass substrate, and has the operation which diffracts an incident beam at a desired include angle. As shown in drawing 8 (a), the narrow beam which carried out vertical incidence to diffracted-light study component 4b in accordance with the optical axis AX is diffracted along all directions with equiangular centering on an optical axis AX, and, specifically, turns into a ring-like beam. Therefore, if the collimated beam of a square cross section carries out incidence to this diffracted-light study component 4b in accordance with an optical axis AX, it will become a zona-orbicularis-like beam as shown in drawing 8 (b). Thus, diffracted-light study component 4b constitutes the flux of light configuration modification member for changing substantially the flux of light from the light source 1 into the zona-orbicularis-like flux of light.

[0061] That is, diffracted-light study component 4b carries out an operation equivalent to the cone prism 4 in the 1st example in that the beam which carried out vertical incidence in accordance with the optical axis AX is deflected along all directions with equiangular centering on an optical axis AX. However, by the cone prism 4 in the 1st example, each beam which constitutes incoming beams from diffracted-light study component 4b of the 2nd example is deflected along all directions to deflecting the whole incoming beams along all directions with equiangular centering on an optical axis AX with equiangular focusing on the incidence axis (parallel to an optical axis AX). Therefore, the afocal zoom lens 5 consists of the 2nd example so that diffracted-light study component 4b and the plane of incidence of the 1st fly eye lens 6 may be optically connected mostly to conjugate.

[0062] In this way, also in the 2nd example, a ring-like light source image is formed in the pupil surface of the afocal zoom lens 5 like the 1st example. And oblique incidence of the almost parallel flux of light injected from the afocal zoom lens 5 is carried out to the plane of incidence of the 1st fly eye lens 6 along all directions with equiangular a core [an optical axis AX]. Consequently, the secondary zona-orbicularis-like light source is formed in a backside [the 2nd fly eye lens 8] focal plane based on the flux of light from the light source 1, without almost carrying out quantity of light loss. Moreover, also in the aperture diaphragm 9 arranged near the backside [the 2nd fly eye lens 8] focal plane, quantity of light loss is hardly generated. Furthermore, the point that zona-orbicularis-like the magnitude and the configuration (zona-orbicularis ratio) of the secondary light source can be changed is the same as the 1st example by changing suitably the scale factor m of the afocal zoom lens 5, and the focal distance fr of a zoom lens 7.

[0063] In addition, to the illumination-light way, it is constituted free [insertion and detachment], and diffracted-light study component 4b consists of the 2nd example possible [other diffracted-light study component 4c and a switch]. When diffracted-light study component 4b is evacuated from an illumination-light way, the usual circular lighting can be performed like the case where cone prism and pyramid prism are evacuated in the 1st example. The case where replaced with diffracted-light study component 4b, and diffracted-light study

component 4c is hereafter set up all over an illumination-light way is explained.
[0064] When using diffracted-light study component 4c as a flux of light configuration modification member, as shown in drawing 9 (a), the narrow beam which carried out vertical incidence in accordance with the optical axis AX is diffracted along four equiangular and specific directions centering on an optical axis AX, and turns into four narrow beams. Therefore, if the collimated beam of a square cross section carries out incidence to this diffracted-light study component 4b in accordance with an optical axis AX, as shown in drawing 9 (b), it will become a 4 pole-like beam. Thus, diffracted-light study component 4c constitutes the flux of light configuration modification member for changing into the four flux of lights which carried out eccentricity of the flux of light from the light source 1 to the optical axis AX. Therefore, four punctiform light source images are formed in the pupil surface of the afocal zoom lens 5 like the case where pyramid prism 4a is used in the 1st example.
[0065] And oblique incidence of the almost parallel flux of light injected from the afocal zoom lens 5 is carried out to the plane of incidence of the 1st fly eye lens 6 along four equiangular and specific directions a core [an optical axis AX]. Consequently, the secondary 4 pole-like light source is formed in a backside [the 2nd fly eye lens 8] focal plane based on the flux of light from the light source 1, without almost carrying out quantity of light loss. Moreover, the secondary light source of the shape of these 4 poles is restricted, suppressing quantity of light loss good by aperture-diaphragm 9a arranged near the backside [the 2nd fly eye lens 8] focal plane. Furthermore, 4 pole-like the magnitude and the configuration of the secondary light source can be changed by changing suitably the scale factor m of the afocal zoom lens 5, and the focal distance fr of a zoom lens 7.
[0066] Drawing 10 is drawing showing roughly the important section configuration of the illumination-light study equipment concerning the 1st modification of the 2nd example, and (b) shows the condition of having expanded the scale factor of the afocal zoom lens 5 rather than the condition of (a). the 1st modification -- the -- only the point of using the micro-lens array as a 1 optical integrator is different from the 2nd example, and other configurations are the same as the 2nd example.
[0067] In the 1st modification shown in drawing 10 , it replaces with the 1st fly eye lens 6, and micro-lens array 6a is used. Micro-lens array 6a is an optical element which consists of a micro lens (microlens) of a large number arranged in all directions, for example, is constituted by performing etching processing to an parallel flat-surface glass plate, and forming a microlens group. Therefore, although each micro lens is minuter than each lens element which constitutes a fly eye lens, it is the same as a fly eye lens at the point that the lens element which has forward refractive power is arranged in all directions. Therefore, micro-lens array 6a does so the same operation as the 1st fly eye lens 6.
[0068] Hereafter, change with the scale factor m of the afocal zoom lens 5 in the case of changing only the configuration (zona-orbicularis ratio A) and the focal distance fr of a zoom lens 7 is explained according to a concrete numerical example, without changing the magnitude (outer-diameter phio) of the secondary zona-orbicularis-like light source in the 1st modification using diffracted-light study component 4b and micro-lens array 6a. In this example of the 2nd numeric value, alpha is made into 7 times whenever [by diffracted-light study component 4b / angle-of-diffraction] (deflecting angle), size a of each micro lens of micro-lens array 6a is set to 0.5mm, and the focal distance f1 of each micro lens is set to 10mm. And outer-diameter phio of the secondary zona-orbicularis-like light source The scale factor m of the afocal zoom lens 5 required to change the zona-orbicularis ratio A to about 0.24 - abbreviation 0.95 and the focal distance fr of a zoom lens 7 are found, respectively, holding uniformly by 96mm. The correspondence relation between the scale factor m of the afocal zoom lens 5, and the zona-orbicularis ratio A of the secondary zona-orbicularis-like light source and the focal distance fr of a zoom lens 7 in the example of the 2nd numeric value is shown in the next table (2).
[0069]
[Table 2]
alpha= 7 times a=0.5mmf1=10mmphio =96mmm A fr0.1 0.94817 49.756780.2 0.916468 80.190260.3 0.881258 113.99270.4 0.846487 147.37230.5 0.812679 179.82790.6 0.779947 211.25130.7

0.748299 241.63320.8 0.717711 270.99750.9 0.688146 299.38011.0 0.659561 326.82111.1 0.631915353.36161.2 0.605165 379.04191.3 0.57927403.9011.4 0.554191 427.97631.5 0.529893 451.30311.6 0.506338 473.91511.7 0.483496 495.84391.8 0.461334 517.11981.9 0.439822 537.77112.00.418933 557.82472.1 0.39864 577.30592.2 0.378918 596.23872.3 0.359744614.64592.4 0.341095 632.5492.5 0.32295649.96822.60. 305289 666.92282.7 0.288092 683.43132.8 0.271343 699.51082.9 0.255023 715.17783.00.239117 730.448 [0070] When comparison reference of a table (1) and the table (2) is carried out, it turns out that the correspondence relation between the scale factor m of the afocal zoom lens 5, and the zona-orbicularis ratio A and the focal distance fr of a zoom lens 7 is in agreement in the example of the 1st numeric value, and the example of the 2nd numeric value. When replacing this with the 1st fly eye lens 6 and using micro-lens array 6a, demonstrating an equivalent operation also numerically with the 1st fly eye lens 6 shows a certain thing for **** by setting up suitably the size a and the focal distance f1 of each micro lens.

[0071] Drawing 11 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 2nd modification of the 2nd example. Only the point which removes the afocal zoom lens 5 and is carrying out contiguity arrangement of diffracted-light study component 4b and the plane of incidence of the 1st fly eye lens 6 in the 2nd modification is different from the 2nd example, and other configurations are the same as the 2nd example. Therefore, in drawing 11 , the same reference mark as drawing 7 is given to the component of the 2nd example, and the element which has the same function. Hereafter, the 2nd modification is explained paying attention to difference with the 2nd example.

[0072] As mentioned above, in the 2nd example, the afocal zoom lens 5 has connected optically diffracted-light study component 4b and the plane of incidence of the 1st fly eye lens 6 to conjugate mostly, and has the function to change the include angle of the incoming beams to the plane of incidence of the 1st fly eye lens 6. Therefore, even if it removes the afocal zoom lens 5 from an illumination-light way and carries out contiguity arrangement of diffracted-light study component 4b and the plane of incidence of the 1st fly eye lens 6, the include angle of the incoming beams to the plane of incidence of the 1st fly eye lens 6 is only specified fixed by whenever [angle-of-diffraction / of diffracted-light study component 4b]. Therefore, although the magnitude of the secondary light source of the shape of zona orbicularis formed in a backside [the 2nd fly eye lens 8] focal plane by changing the focal distance of a zoom lens 7 can be changed in the 2nd modification, the zona-orbicularis ratio cannot be changed.

[0073] Drawing 12 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the 3rd example of this invention. The 3rd example has a configuration similar to the 1st example. however -- the 1st example -- the -- although the fly eye lens is used as a 2 optical integrator -- the 2nd example -- the -- it is only fundamentally different to use the optical integrator (only henceforth a "rod mold integrator") of a rod mold as a 2 optical integrator. Therefore, in drawing 12 , the same reference mark as drawing 1 is given to the component of the 1st example, and the element which has the same function. Hereafter, the 3rd example is explained paying attention to difference with the 1st example.

[0074] In the 3rd example, while attaching condenser-lens 7a into the optical path between a zoom lens 7 and rod mold integrator 8a, replacing with the capacitor optical system 10 corresponding to replacing with the 2nd fly eye lens 8, and using rod mold integrator 8a and installing image formation optical-system 10a, the aperture diaphragm for a limit of the secondary light source is removed. Here, the synthetic optical system which consists of a zoom lens 7 and condenser-lens 7a has connected optically a backside [the 1st fly eye lens 6] focal plane, and the plane of incidence of rod mold integrator 8a to conjugate mostly. Moreover, image formation optical-system 10a has connected optically the injection side and mask 11 of rod mold integrator 8a to conjugate mostly.

[0075] Rod mold integrator 8a is the glass rod of the internal reflection mold which consists of a glass ingredient like quartz glass or fluorite, and forms the light source image of the number according to the number of internal reflection along a field parallel to rod plane of incidence through a condensing point using total reflection, the interface, i.e., the inside, of the interior and

the exterior. Here, although most light source images formed are virtual images, only a central (condensing point) light source image turns into a real image. That is, the flux of light which carried out incidence to rod mold integrator 8a is divided in the include-angle direction by internal reflection, and the secondary light source which consists of many light source images along a field parallel to the plane of incidence through a condensing point is formed. In the case of the 3rd example, when the cone prism 4 is used as a flux of light configuration modification member, the secondary zona-orbicularis-like light source is formed, and when pyramid prism 4a is used, the secondary 4 pole-like light source is formed.
[0076] The flux of light from the secondary light source formed in the incidence side of rod mold integrator 8a carries out homogeneity lighting of the mask 11 with which the predetermined pattern was formed through image formation optical-system 10a, after being superimposed in the injection side. As mentioned above, image formation optical-system 10a has connected optically the injection side and mask 11 (as a result, wafer 13) of rod mold integrator 8a to conjugate mostly. Therefore, on a mask 11, the radiation field of the shape of a rectangle [**** / the cross-section configuration of rod mold integrator 8a] is formed.
[0077] Thus, suppressing quantity of light loss good like the 1st example also in the 3rd example Zona-orbicularis deformation lighting can be performed by using the cone prism 4 as a flux of light configuration modification member. By using pyramid prism 4a as a flux of light configuration modification member, 4 pole deformation lighting can be performed and the usual circular lighting can be performed by evacuating a flux of light configuration modification member from an illumination-light way. Moreover, the magnitude and the configuration of the secondary light source can be changed by changing suitably the scale factor m of the afocal zoom lens 5, and the focal distance fr of a zoom lens 7.
[0078] As mentioned above, in an above-mentioned example and an above-mentioned modification, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of deformation lighting can be changed by easy variable power actuation, suppressing the quantity of light loss by the aperture diaphragm good. Therefore, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions.
[0079] Since the wafer which passed through the process (photolithography process) of exposure by the aligner of each example and a modification should pass the process to develop, a wafer process ends it through the process of resist removal of removing the unnecessary resist after the process of etching of removing parts other than the developed resist, and the process of etching etc. And finally termination of a wafer process manufactures the semiconductor devices (LSI etc.) as a device like an actual erector through each process, such as dicing which was able to be burned and which cuts and chip-izes a wafer for every circuit, bonding which gives wiring etc. to each chip, and packaging which carries out packaging for every chip.
[0080] In addition, although the above explanation showed the example which manufactures a semiconductor device according to the photolithography process in the wafer process which used the projection aligner, a liquid crystal display component, the thin film magnetic head, and image sensors (CCD etc.) can be manufactured as a semiconductor device according to the photolithography process using an aligner. In this way, since projection exposure can be performed under good exposure conditions in the case of the exposure approach of manufacturing a semiconductor device using the illumination-light study equipment of this invention, a good semiconductor device can be manufactured.
[0081] In addition, in performing circular opening lighting in an above-mentioned example and an above-mentioned modification, it is desirable to evacuate a flux of light configuration modification member out of an illumination-light way. By evacuating a flux of light configuration modification member (4, 4a, 4b), it can consider as the so-called double fly eye structure of a

system which is indicated by JP,58-147708,A. Under the present circumstances, in the equipment of a configuration as illustrated to drawing 1 , drawing 7 , and drawing 12 , the afocal zoom lens 5 may be evacuated to coincidence. Moreover, in the equipment of a configuration as illustrated to drawing 11 , the 1st fly eye lens 6 may be evacuated to coincidence, and you may insert all over an illumination-light way to lighting conditions instead by making another suitable fly eye lens into the 1st fly eye lens. Moreover, although the prism which has a cone concave surface as cone prism is used in an above-mentioned example and an above-mentioned modification, the prism which has a cone convex can also be used. The prism which has a pyramid convex can also be similarly used about pyramid prism.

[0082] Moreover, although an above-mentioned example and an above-mentioned modification explained this invention taking the case of the projection aligner equipped with illumination-light study equipment, it is clear that this invention is applicable to the common illumination-light study equipment for carrying out homogeneity lighting of the irradiated planes other than a mask. Furthermore, although the above example and modification showed the example using the ArF excimer laser which supplies the KrF excimer laser and the 193nm wavelength light which supply 248nm wavelength light as the light source, it cannot be overemphasized that this invention is applicable also to equipment equipped with the light sources other than this. For example, F2 which supplies 157nm wavelength light It is also possible to use the light source unit which consists of combination of laser light sources, such as laser, or the laser light source which supplies the light of predetermined wavelength, and the nonlinear optical element which changes the light from the laser light source into light with a short wavelength of 200nm or less etc. as a light source means of this invention.

[0083]

[Effect of the Invention] As explained above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of deformation lighting can be changed by easy variable power actuation, suppressing the quantity of light loss by the aperture diaphragm good.

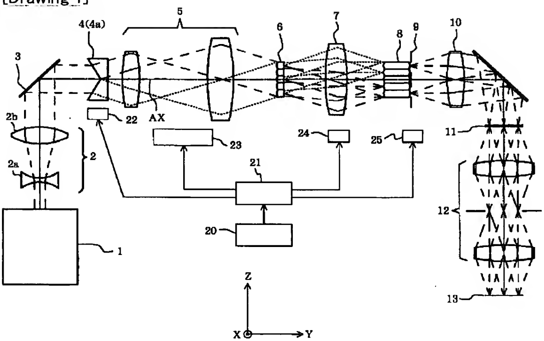
[0084] Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure approach which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good semiconductor device can be manufactured.

[Translation done.]

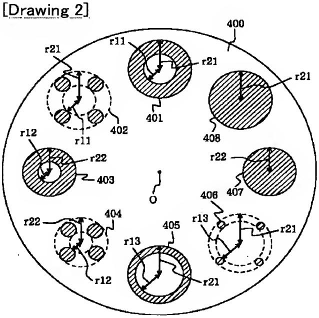
* NOTICES *

DRAWINGS

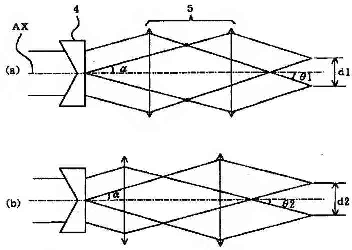
[Drawing 1]



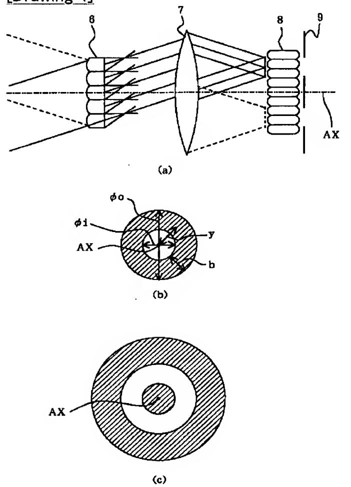
[Drawing 2]



[Drawing 3]

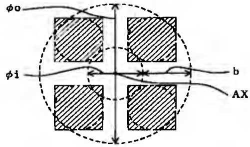


[Drawing 4]

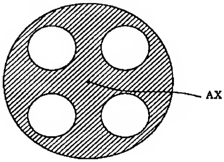


[Drawing 6]

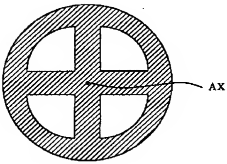
(a)



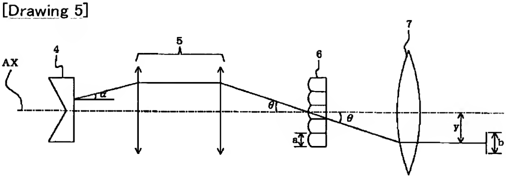
(b)



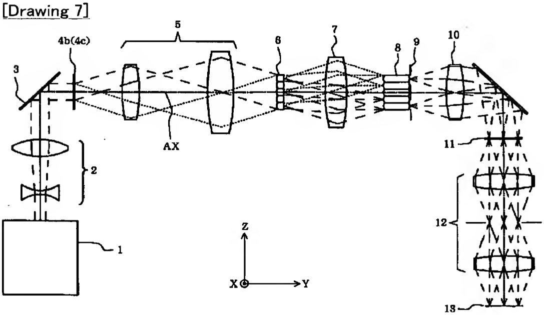
(c)



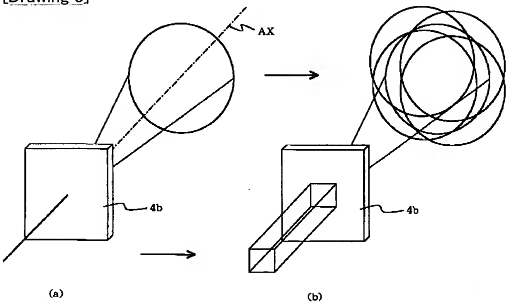
[Drawing 5]



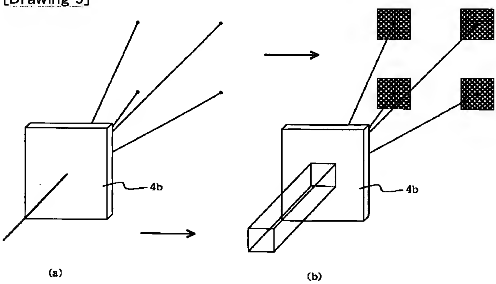
[Drawing 7]



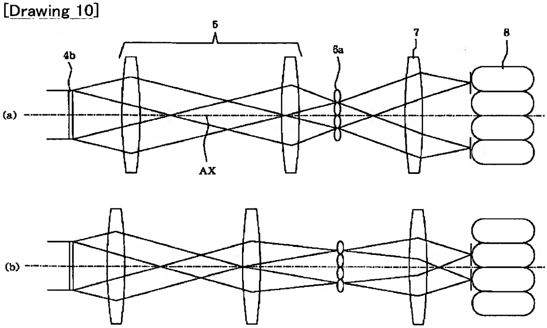
[Drawing 8]



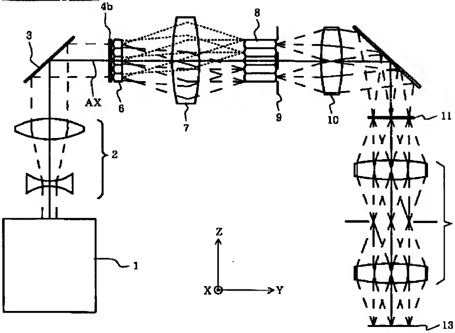
[Drawing 9]



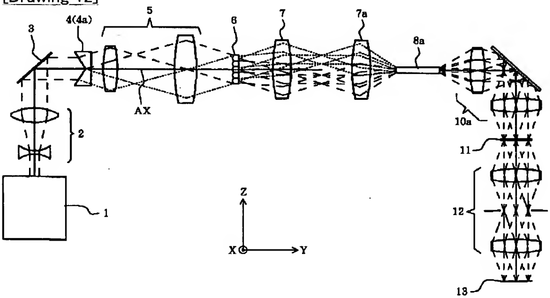
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]

PATENT ABSTRACTS OF JAPAN

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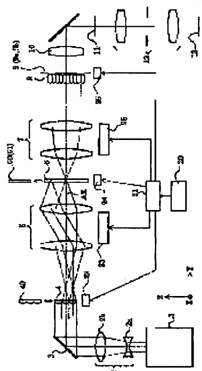
(71)Applicant : NIKON CORP
(72)Inventor : TANITSU OSAMU

(54) ILLUMINATION OPTICAL SYSTEM AND EXPOSURE SYSTEM PROVIDED THEREWITH

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an illumination optical system capable of producing converted illumination such as zonal illumination, quadruple illumination while reducing an optical loss at an aperture to a small amount.
SOLUTION: This illumination optical system includes angled optical flux forming means 4, 5 for converting an optical flux from a light source 1 into a plurality of optical fluxes having angle components, optical flux shape converting means 6, 7 for forming, for example, zonal optical intensity distribution based on the optical fluxes, an optical integrator 8 which receives the optical fluxes to form a secondary light source having a zonal optical intensity distribution, and a light introducing optical system 10 for introducing the optical fluxes from the optical integrator 8 into a mask 11.



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[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] In the illumination-light study equipment for illuminating the mask which has a predetermined pattern The flux of light from the light source means and said light source means for supplying the flux of light is changed into the flux of light which has two or more include-angle components to a criteria optical axis. It is based on the flux of light which has said two or more include-angle components through the include-angle flux of light means forming which carries out incidence to the 1st predetermined side, and said 1st predetermined side. The flux of light configuration conversion means for forming optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis on the 2nd predetermined side, The optical integrator which forms the secondary light source of said optical intensity distribution and the optical intensity distribution which have this inclination in response to said flux of light which passed through said 2nd predetermined side, Illumination-light study equipment characterized by having the light guide optical system for leading the flux of light from this optical integrator to said mask.
[Claim 2] In the illumination-light study equipment for illuminating the mask which has a predetermined pattern The emission flux of light formation component for changing said abbreviation parallel flux of light from the light source means and this light source means for supplying the abbreviation parallel flux of light into the emission flux of light which has two or more include-angle components to a criteria optical axis, The 1st optical system for condensing said emission flux of light and leading to the 1st predetermined side, and the flux of light sensing element arranged near [said] the 1st predetermined side, The 2nd optical system for leading the flux of light from this flux of light sensing element to the 2nd predetermined side, The optical integrator which forms the secondary light source of optical predetermined intensity distribution in response to said flux of light which passed through said 2nd predetermined side, It has the light guide optical system for leading the flux of light from this optical integrator to said mask. Said 1st and 2nd optical system It has the 1st and 2nd variable power optical system. Said flux of light sensing element and said 2nd optical system Illumination-light study equipment characterized by forming optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis on said 2nd predetermined side based on the flux of light from said 1st optical system.
[Claim 3] In the illumination-light study equipment for illuminating the mask which has a predetermined pattern The emission flux of light formation component for changing said abbreviation parallel flux of light from the light source means and this light source means for supplying the abbreviation parallel flux of light into the emission flux of light which has two or more include-angle components to a criteria optical axis, The 1st optical system for condensing said emission flux of light and leading to the 1st predetermined side, and the flux of light sensing element arranged near [said] the 1st predetermined side, The 2nd optical system for leading the flux of light from this flux of light sensing element to the 2nd predetermined side, The optical integrator which forms the secondary light source of optical predetermined intensity distribution

in response to said flux of light which passed through said 2nd predetermined side, It has the light guide optical system for leading the flux of light from this optical integrator to said mask. Said 1st optical system Said emission flux of light formation component and said 1st predetermined side are optically made conjugate. Said flux of light sensing element and said 2nd optical system Illumination-light study equipment characterized by forming optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis on said 2nd predetermined side based on the flux of light from said 1st optical system.
[Claim 4] The aligner characterized by equipping claim 1 thru/or any 1 term of 3 with the illumination-light study equipment of a publication, and the projection optics for carrying out projection exposure of the pattern of said mask to up to a photosensitive substrate.

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the suitable illumination-light study equipment for the aligner for manufacturing devices, such as a semiconductor device, an image sensor, a liquid crystal display component, or the thin film magnetic head, at a lithography process especially about the aligner equipped with illumination-light study equipment and this illumination-light study equipment.
[0002]
[Description of the Prior Art] In this kind of typical aligner, the flux of light injected from the light source carries out incidence to a fly eye lens, and forms the secondary light source which becomes an after that side focal plane from many light source images. After the flux of light from the secondary light source is restricted through the aperture diaphragm arranged near the backside [a fly eye lens] focal plane, incidence of it is carried out to a condensing lens. An aperture diaphragm restricts to the configuration of the secondary light source, the configuration of a request of magnitude, or magnitude according to desired lighting conditions (exposure conditions).
[0003] The flux of light condensed with the condensing lens illuminates in superposition the mask with which the predetermined pattern was formed. Image formation of the light which penetrated the pattern of a mask is carried out on a wafer through projection optics. In this way, on a wafer, projection exposure (imprint) of the mask pattern is carried out. In addition, it is indispensable to integrate highly the pattern formed in the mask and to imprint this detailed pattern correctly on a wafer to acquire uniform illumination distribution on a wafer.
[0004] In recent years, the technique of changing the magnitude of the secondary light source formed of a fly eye lens, and changing the coherency sigma of lighting (sigma value = the pupil diameter of the diameter of an aperture diaphragm / projection optics or incidence side numerical aperture of the injection side numerical aperture / projection optics of a sigma value = illumination-light study system) attracts attention by changing the magnitude of opening (light transmission section) of the aperture diaphragm arranged at the injection side of a fly eye lens. Moreover, by setting up the configuration of opening of the aperture diaphragm arranged at the injection side of a fly eye lens the shape of zona orbicularis, and in the shape of 4 holes (the shape of namely, 4 poles), the configuration of the secondary light source formed of a fly eye lens is restricted the shape of zona orbicularis, and in the shape of 4 poles, and the technique of raising the depth of focus and resolution of projection optics attracts attention.
[0005]
[Problem(s) to be Solved by the Invention] As mentioned above, with the conventional technique, in order to restrict the configuration of the secondary light source the shape of zona orbicularis, and in the shape of 4 poles and to perform deformation lighting (zona-orbicularis deformation lighting and 4 pole deformation lighting), the aperture diaphragm which has opening of the shape of the shape of zona orbicularis or 4 poles has restricted the flux of light from the comparatively big secondary light source formed of the fly eye lens. If it puts in another way, with the zona-orbicularis deformation lighting or 4 pole deformation lighting in the conventional technique, the

considerable part of the flux of light from the secondary light source will be covered by the aperture diaphragm, and will not contribute to lighting (exposure). Consequently, there was un-arranging [that the illuminance on a mask and a wafer fell and the throughput as an aligner also fell by quantity of light loss in an aperture diaphragm].
[0006] This invention is made in view of the above-mentioned technical problem, and it aims at offering the aligner equipped with the illumination-light study equipment and this illumination-light study equipment which can perform deformation lighting like zona-orbicularis lighting or 4 pole lighting, suppressing the quantity of light loss in an aperture diaphragm good.
[0007]
[Means for Solving the Problem] In order to solve said technical problem, in this invention concerning claim 1 In the illumination-light study equipment for illuminating the mask which has a predetermined pattern The flux of light from the light source means and said light source means for supplying the flux of light is changed into the flux of light which has two or more include-angle components to a criteria optical axis. It is based on the flux of light which has said two or more include-angle components through the include-angle flux of light means forming which carries out incidence to the 1st predetermined side, and said 1st predetermined side. The flux of light configuration conversion means for forming optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis on the 2nd predetermined side, The optical integrator which forms the secondary light source of said optical intensity distribution and the optical intensity distribution which have this inclination in response to said flux of light which passed through said 2nd predetermined side, The illumination-light study equipment characterized by having the light guide optical system for leading the flux of light from this optical integrator to said mask is offered.
[0008] In addition, in this invention concerning claim 1, it is desirable to consider as which configuration of the following (1) - (18).
(1) As for said include-angle flux of light means forming, it is desirable to change said two or more include-angle components of said flux of light which carries out incidence to said 1st predetermined side.
(2) As for said flux of light which carries out incidence to said 1st predetermined side, it is desirable that it is the convergence flux of light as a whole.
(3) As for said include-angle flux of light means forming, it is desirable to have an emission flux of light formation component for changing the almost parallel flux of light from said light source means into the flux of light emitted at various include angles to said criteria optical axis and the 1st optical system for condensing the emission flux of light formed through said emission flux of light formation component, and leading to said 1st predetermined side.
[0009] (4) As for said 1st optical system, in the configuration of the above (3), it is desirable to make conjugate optically said emission flux of light formation component and said 1st predetermined side.
(5) As for said 1st optical system, in the above (3) or the configuration of (4), it is desirable to have variable power optical system.
(6) As for said variable power optical system, in the configuration of the above (5), it is desirable to change said two or more include-angle components of said flux of light which carries out incidence to said 1st predetermined side.
(7) optical intensity distribution [in / on which configuration of above-mentioned (3) - (6), and / the pupil surface of said 1st optical system] -- about -- it is desirable that he is Mr. one.
(8) As for said variable power optical system, in the configuration of the above (5), it is desirable to change the width of face, without changing the main height of the light source of the shape of zona orbicularis formed as said secondary light source, or two or more light sources.
[0010] (9) The above (3) As for said emission flux of light formation component, in which configuration of - (8), it is desirable to be constituted free [insertion and detachment] to an illumination-light way.
(10) The above (3) As for said emission flux of light formation component, in which configuration of - (9), it is desirable to carry out wavefront splitting of the flux of light from said light source

means.
(11) In the configuration of claim 1, said emission flux of light formation component has the micro-lens array constituted free [insertion and detachment] to the illumination-light way, and as for said 1st optical system, it is desirable to have the 1st variable power optical system for changing the width of face, without changing the main height of the light source of the shape of zona orbicularis formed as said secondary light source, or two or more light sources.
(12) As for said 1st variable power optical system, in the configuration of the above (11), it is desirable to have the afocal zoom lens which connects optically the focal plane of said micro-lens array and said 1st predetermined side to conjugate.
[0011] (13) Claim 1 or the above (1) As for said flux of light configuration conversion means, in which configuration of - (12), it is desirable to have the flux of light sensing element arranged near [said] the 1st predetermined side and the 2nd optical system which leads the flux of light from this flux of light sensing element to said 2nd predetermined side.
(14) As for said 2nd optical system, in the configuration of the above (13), it is desirable to have variable power optical system.
In the above (13) or the configuration of (14) (15) Said flux of light sensing element It is desirable to form optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in the field which includes said criteria optical axis in a far field (or Fraunhofer diffraction field), or the field near said criteria optical axis. As for said 2nd optical system, it is desirable to make said optical intensity distribution formed in said far field (or Fraunhofer diffraction field) form on said 2nd predetermined side.
[0012] (16) The above (13) As for said flux of light sensing element, in which configuration of - (15), it is desirable to be prepared free [insertion and detachment] to an illumination-light way.
(17) Claim 1 or the above (1) In which configuration of - (12) said flux of light configuration conversion means The flux of light sensing element for changing the thin flux of light which carries out incidence to said 1st predetermined side into the flux of light or two or more flux of lights of the shape of a ring emitted to a radial, It is desirable to have the 2nd optical system for forming two or more radiation fields which carried out eccentricity to the plane of incidence of said optical integrator to zona-orbicularis-like a radiation field or said criteria optical axis based on the flux of light or two or more flux of lights of the shape of a ring formed through said flux of light sensing element.
In the configuration of the above (17) (18) Said flux of light sensing element It has the diffracted-light study component with which it was constituted free [insertion and detachment] to the illumination-light way, and the diffraction side was positioned in said 1st predetermined side. Said 2nd optical system It is desirable to have the 2nd variable power optical system for changing the outer diameter, without changing the zona-orbicularis ratio of the light source of the shape of zona orbicularis formed as said secondary light source, or two or more light sources.
[0013] Moreover, it sets to the illumination-light study equipment for illuminating the mask which has a predetermined pattern in this invention concerning claim 2. The emission flux of light formation component for changing said abbreviation parallel flux of light from the light source means and this light source means for supplying the abbreviation parallel flux of light into the emission flux of light which has two or more include-angle components to a criteria optical axis, The 1st optical system for condensing said emission flux of light and leading to the 1st predetermined side, and the flux of light sensing element arranged near [said] the 1st predetermined side, The 2nd optical system for leading the flux of light from this flux of light sensing element to the 2nd predetermined side, The optical integrator which forms the secondary light source of optical predetermined intensity distribution in response to said flux of light which passed through said 2nd predetermined side, It has the light guide optical system for leading the flux of light from this optical integrator to said mask. Said 1st and 2nd optical system It has the 1st and 2nd variable power optical system. Said flux of light sensing element and said 2nd optical system Based on the flux of light from said 1st optical system, the illumination-light study equipment characterized by forming optical intensity distribution which become strong on said 2nd predetermined side is offered in the periphery section which is weakly separated from

said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis.
[0014] In addition, in this invention concerning claim 2, it is desirable to consider as which configuration of the following (19) - (25).
(19) As for said emission flux of light formation component, in the configuration of claim 2, it is desirable to carry out wavefront splitting of said abbreviation parallel flux of light from said light source means.
(20) As for the flux of light led to said 1st predetermined side, in the configuration of claim 2 or the above (19), it is desirable that it is the convergence flux of light as a whole.
[0015] (21) Claim 2 or the above (19) As for said 1st optical system, in which configuration of - (20), it is desirable to make conjugate optically said emission flux of light formation component and said 1st predetermined side.
(22) Claim 2 or the above (19) In which configuration of - (21) said flux of light sensing element It is desirable to form optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in the field which includes said criteria optical axis in a far field (or Fraunhofer diffraction field), or the field near said criteria optical axis. As for said 2nd optical system, it is desirable to make said optical intensity distribution formed in said far field (or Fraunhofer diffraction field) form on said 2nd predetermined side.
[0016] (23) Claim 2 or the above (19) It sets they to be [any of the configuration of - (22)], and, as for said 1st optical system, it is desirable to change said two or more include-angle components of said flux of light which carries out incidence to said 1st predetermined side.
(24) Claim 2 or the above (19) It sets they to be [any of the configuration of - (22)], and as for said 1st variable power optical system, it is desirable to change the width of face, without changing the main height of said optical intensity distribution formed on said 2nd predetermined side.
(25) Claim 2 or the above (19) It sets they to be [any of the configuration of - (23)], and it is desirable to change the distance from said criteria optical axis to said outside, said 2nd variable power optical system maintaining uniformly the ratio of the distance from said criteria optical axis in said optical intensity distribution formed on said 2nd predetermined side to the inside, and the distance from said criteria optical axis to an outside.
[0017] Furthermore, it sets to the illumination-light study equipment for illuminating the mask which has a predetermined pattern in this invention concerning claim 3. The emission flux of light formation component for changing said abbreviation parallel flux of light from the light source means and this light source means for supplying the abbreviation parallel flux of light into the emission flux of light which has two or more include-angle components to a criteria optical axis, The 1st optical system for condensing said emission flux of light and leading to the 1st predetermined side, and the flux of light sensing element arranged near [said] the 1st predetermined side, The 2nd optical system for leading the flux of light from this flux of light sensing element to the 2nd predetermined side, The optical integrator which forms the secondary light source of optical predetermined intensity distribution in response to said flux of light which passed through said 2nd predetermined side, It has the light guide optical system for leading the flux of light from this optical integrator to said mask. Said 1st optical system Said emission flux of light formation component and said 1st predetermined side are optically made conjugate. Said flux of light sensing element and said 2nd optical system Based on the flux of light from said 1st optical system, the illumination-light study equipment characterized by forming optical intensity distribution which become strong on said 2nd predetermined side is offered in the periphery section which is weakly separated from said criteria optical axis in a field including said criteria optical axis, or the field near said criteria optical axis.
[0018] In addition, in the 3rd invention concerning claim 3, it is desirable to consider as which configuration of the following (26) - (33).
(26) As for said 1st optical system, in the configuration of claim 3, it is desirable to have the 1st variable power optical system.
(27) As for said 1st variable power optical system, in the configuration of the above (26), it is desirable to have an afocal zoom lens.

[0019] (28) As for said 1st variable power optical system, in the above (26) or the configuration of (27), it is desirable to change the width of face, without changing the main height of said optical intensity distribution formed on said 2nd predetermined side.
(29) optical intensity distribution [in / on which configuration of claim 3 and above-mentioned (26) - (28), and / the pupil surface of said 1st optical system] -- about -- it is desirable that he is Mr. one.
(30) As for said 2nd optical system, in which configuration of claim 3 and above-mentioned (26) - (29), it is desirable to have the 2nd variable power optical system.
(31) As for said 2nd variable power system, in the configuration of the above (30), it is desirable to make substantially said flux of light sensing element and said 2nd predetermined side the relation of the Fourier transform.
[0020] (32) Claim 3 or the above (26) It sets they to be [any of the configuration of - (31)], and it is desirable to change the distance from said criteria optical axis to said outside, said 2nd variable power optical system maintaining uniformly the ratio of the distance from said criteria optical axis in said optical intensity distribution formed on said 2nd predetermined side to the inside, and the distance from said criteria optical axis to an outside.
(33) Claim 3 or the above (26) It sets they to be [any of the configuration of - (32)]. Said flux of light sensing element It is desirable to form optical intensity distribution which become strong in the periphery section which is weakly separated from said criteria optical axis in the field which includes said criteria optical axis in a far field (or Fraunhofer diffraction field), or the field near said criteria optical axis. As for said 2nd optical system, it is desirable to make said optical intensity distribution formed in said far field (or Fraunhofer diffraction field) form on said 2nd predetermined side.
[0021] Moreover, it is desirable to consider as which configuration of the following (34) - (35) at claims 1, 2, or 3 and a list in this invention concerning any of the configuration of above-mentioned (1) - (33) they are.
(34) It is desirable to set at claims 1, 2, or 3 and a list they to be [any of the configuration of above-mentioned (1) - (33)], and to position the plane of incidence of said optical integrator to said 2nd predetermined side.
(35) Set at claims 1, 2, or 3 and a list they to be [any of the configuration of above-mentioned (1) - (34)], and, as for said light guide optical system, it is desirable to have the capacitor group which condenses the flux of light from said secondary light source, and illuminates the 3rd predetermined side in superposition, and the relay group which carries out image formation of the image of said 3rd predetermined side on said mask.
[0022] Moreover, this invention is an aligner for imprinting the pattern on a mask on a photosensitive substrate, and is equipped with claims 1, 2, or 3, the illumination-light study equipment applied to any of the configuration of above-mentioned (1) - (35) they are at a list, and the projection optics for imprinting said pattern on said photosensitive substrate. In the above-mentioned aligner, it is desirable to have further the control means for controlling at least one of said emission flux of light formation component, said 1st variable power optical system, said flux of light sensing element, and said 2nd variable power optical system based on the information about the pattern of said mask.
[0023] Moreover, this invention is the exposure approach for imprinting the pattern on a mask on a photosensitive substrate, illuminates said mask with claims 1, 2, or 3 and the illumination-light study equipment applied to any of the configuration of above-mentioned (1) - (35) they are at a list, and imprints said illuminated pattern on said photosensitive substrate. In the above-mentioned exposure approach, it is desirable to control at least one of said emission flux of light formation component, said 1st variable power optical system, said flux of light sensing element, and said 2nd variable power optical system based on the information about the pattern of said mask.
[0024]
[Embodiment of the Invention] With the typical operation gestalt of this invention, include-angle flux of light means forming and a flux of light configuration conversion means are arranged in the optical path between a light source means and an optical integrator. Include-angle flux of light

means forming consists of optical system like the afocal zoom lens for leading to the diffraction side of an emission flux of light formation component like the micro-lens array for changing into the flux of light which emits [as opposed to / specifically / a criteria optical axis] the almost parallel flux of light from a light source means at various include angles, and the diffracted-light study component as a flux of light sensing element which condenses the emission flux of light formed through the micro-lens array, and is mentioned later. Therefore, after the almost parallel flux of light from a light source means minds a micro-lens array and an afocal zoom lens, it turns into the flux of light which has two or more include-angle components to a criteria optical axis, and carries out incidence to a diffracted-light study component.
[0025] A flux of light sensing element like the diffracted-light study component for on the other hand changing a flux of light configuration conversion means into the flux of light or two or more flux of lights of the shape of a ring which emits to a radial the thin flux of light which carries out incidence, It is based on the flux of light or two or more flux of lights of the shape of a ring formed through the diffracted-light study component. It consists of optical system like the zoom lens for forming two or more radiation fields which carried out eccentricity to the plane of incidence of an optical integrator like a fly eye lens to zona-orbicularis-like a radiation field or a criteria optical axis. Although two or more radiation fields or the secondary light source which carried out eccentricity to the criteria optical axis generally means the radiation field or the secondary light source of the shape of the shape for example, of 2 poles, or a multipole (the shape of the shape of the shape of 3 poles, and 4 poles, ..., 8 poles, ..), the following explanation explains as that in which 4 pole-like a radiation field or the secondary light source is formed in instantiation.
[0026] In this way, a zona-orbicularis-like radiation field or a 4 pole-like radiation field is formed in the plane of incidence of a fly eye lens of an operation with the include-angle flux of light means forming which consists of a micro-lens array and an afocal zoom lens, and the flux of light configuration conversion means which consists of a diffracted-light study component and a zoom lens. Consequently, similarly the secondary light source of the shape of the shape of zona orbicularis and 4 poles is formed in a backside [a fly eye lens] focal plane. Thus, the flux of light from the secondary light source of the shape of the shape of zona orbicularis formed of the fly eye lens and 4 poles illuminates in superposition the mask which is an irradiated plane, after being restricted by the aperture diaphragm which has opening according to the magnitude and the configuration of the secondary light source.
[0027] Thus, in this invention, the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be formed, without almost carrying out quantity of light loss based on the flux of light from a light source means. Consequently, zona-orbicularis deformation lighting and 4 pole deformation lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the flux of light from the secondary light source good. In addition, it cannot be overemphasized that the usual circular lighting can be performed, suppressing quantity of light loss good by evacuating a micro-lens array from an illumination-light way.
[0028] Moreover, in this invention, both the outer diameters and zona-orbicularis ratios of the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be changed by changing the scale factor of an afocal zoom lens. Furthermore, the outer diameter can be changed by changing the focal distance of a zoom lens, without changing the zona-orbicularis ratio of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles. Consequently, only the zona-orbicularis ratio can be changed by changing suitably the scale factor of an afocal zoom lens, and the focal distance of a zoom lens, without changing the outer diameter of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles.

[0029] As mentioned above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the secondary light source good. In addition, the parameter (the magnitude and the configuration of the secondary light source which were restricted) of

deformation lighting can be changed by easy actuation of changing the scale factor of an afocal zoom lens, or changing the focal distance of a zoom lens, suppressing the quantity of light loss by the aperture diaphragm good.

[0030] Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure approach which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good device can be manufactured.

[0031] The example of this invention is explained based on an accompanying drawing. Drawing 1 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the example of this invention. In drawing 1 , the X-axis is set [the Z-axis] up in the direction perpendicular to the space of drawing 1 for the Y-axis in a wafer side in the direction parallel to the space of drawing 1 in a wafer side along the direction of a normal of the wafer 13 which is a photosensitive substrate, respectively. In addition, in drawing 1 , it is set up so that illumination-light study equipment may perform zona-orbicularis lighting.

[0032] The aligner of drawing 1 is equipped with the excimer laser which supplies wavelength (248nm or 193nm) of light as the light source 1 for supplying exposure light (illumination light). The almost parallel flux of light injected along with the Z direction from the light source 1 has the cross section of the shape of a rectangle prolonged long and slender along the direction of X, and it carries out incidence to the beam expander 2 which consists of cylindrical-lens 2a of a pair, and 2b. Each cylindrical-lens 2a and 2b have negative refractive power and forward refractive power in the space of drawing 1 (inside of YZ flat surface), respectively, and function as a plane-parallel plate in the field which intersects perpendicularly with space including an optical axis AX (inside of XZ flat surface). Therefore, the flux of light which carried out incidence to the beam expander 2 is expanded in the space of drawing 1 , and is orthopedically operated by the flux of light which has the cross section of the shape of a predetermined rectangle.

[0033] After the almost parallel flux of light through the beam expander 2 as plastic surgery optical system is deflected in the direction of Y by the bending mirror 3, incidence of it is carried out to the micro-lens array 4 for zona-orbicularis deformation lighting. The micro-lens array 4 is an optical element which consists of micro-lens (microlens) 4a which has the forward refractive power of the shape of a forward hexagon of a large number arranged densely and in all directions, as shown in drawing 1 and drawing 2 . Generally, a micro-lens array is constituted by performing etching processing to for example, an parallel flat-surface glass plate, and forming a microlens group.

[0034] Here, each micro lens which constitutes a micro-lens array is minuter than each lens element which constitutes a fly eye lens. Moreover, unlike the fly eye lens which consists of a lens element isolated mutually, the micro-lens array is formed in one, without isolating many micro lenses mutually. However, the micro-lens array is the same as a fly eye lens at the point that the lens element which has forward refractive power is arranged in all directions. In addition, in drawing 1 and drawing 2 , there are also very few twists and the number of micro-lens 4a which constitutes the micro-lens array 4 for clear-izing of a drawing is actually set up.

[0035] Therefore, the flux of light which carried out incidence to the micro-lens array 4 is divided by many micro lenses two-dimensional, and one light source image is formed in a backside [each micro lens] focal plane, respectively. The flux of light from the light source image of a large number formed in the backside [the micro-lens array 4] focal plane turns into the emission flux of light which has a forward hexagon-like cross section, respectively, and carries out incidence to the afocal zoom lens 5. Thus, the micro-lens array 4 constitutes the emission flux of light formation component for changing the almost parallel flux of light from the light source 1 into the flux of light emitted at various include angles to an optical axis AX.

[0036] In addition, to the illumination-light way, it is constituted free [insertion and

detachment], and the micro-lens array 4 is constituted possible [the micro-lens array 40 for 4 pole deformation lighting, and a switch]. About the configuration and operation of the micro-lens array 40 for 4 pole deformation lighting, it mentions later. Moreover, maintaining an afocal system (non-focal optical system), the afocal zoom lens 5 is constituted so that a scale factor can be continuously changed in the predetermined range.

[0037] Here, evacuation from the illumination-light way of the switch and each micro-lens arrays 4 and 40 of the micro-lens array 4 for zona-orbicularis deformation lighting and the micro-lens array 40 for 4 pole deformation lighting is performed by the 1st drive system 22 which operates based on the command from a control system 21. Moreover, scale-factor change of the afocal zoom lens 5 is performed by the 2nd drive system 23 which operates based on the command from a control system 21.

[0038] Incidence of the flux of light through the afocal zoom lens 5 is carried out to the diffracted-light study component (DOE) 6 for zona-orbicularis deformation lighting. The emission flux of light from each light source image formed in the backside [the micro-lens array 4] focal plane at this time is converged on the diffraction side of the diffracted-light study component 6, with a forward hexagon-like cross section maintained. That is, the afocal zoom lens 5 has connected optically the backside [the micro-lens array 4] focal plane, and the diffraction side of the diffracted-light study component 6 to conjugate. And the numerical aperture of the flux of light which condenses to one on the diffraction side of the diffracted-light study component 6 changes depending on the scale factor of the afocal zoom lens 5.

[0039] Generally, a diffracted-light study component is constituted by forming the level difference which has the pitch of wavelength extent of exposure light (illumination light) in a glass substrate, and has the operation which diffracts an incident beam at a desired include angle. A radial is made to specifically emit the thin flux of light which carried out vertical incidence to the optical axis AX at parallel according to one predetermined angle of divergence, as the diffracted-light study component 6 for zona-orbicularis deformation lighting is shown in drawing 3 (a). A paraphrase diffracts with equiangular the thin flux of light which carried out vertical incidence to the diffracted-light study component 6 in accordance with the optical axis AX along all directions centering on an optical axis AX. Consequently, the thin flux of light which carried out vertical incidence to the diffracted-light study component 6 is changed into the emission flux of light which has a ring-like cross section. Thus, the diffracted-light study component 6 constitutes the flux of light sensing element for changing the thin flux of light which carries out incidence into the flux of light of the shape of a ring emitted to a radial.

[0040] Therefore, if the thick parallel flux of light carries out vertical incidence to the diffracted-light study component 6 as shown in drawing 3 (b), the ring-like image (ring-like light source image) 32 will be too formed in the focal location of the lens 31 arranged behind the diffracted-light study component 6. That is, the diffracted-light study component 6 forms optical ring-like intensity distribution in a far field (or Fraunhofer diffraction field). Moreover, a lens 31 makes the optical intensity distribution of the shape of a ring formed in a far field (or Fraunhofer diffraction field) form on an after that side focal plane.

[0041] Here, if the thick parallel flux of light which carries out incidence to the diffracted-light study component 6 is leaned to an optical axis AX as shown in drawing 3 (c), the image of the shape of a ring formed in the focal location of a lens 31 will move. That is, if the thick parallel flux of light which carries out incidence to the diffracted-light study component 6 inclines along a predetermined field (drawing 3 space), the image 33 of the shape of a ring formed in the focal location of a lens 31 will move to the sense with the core opposite to the sense to which the flux of light inclines along a predetermined field, without changing the magnitude.

[0042] As mentioned above, the emission flux of light from each light source image formed in the backside [the micro-lens array 4] focal plane is converged on the diffraction side of the diffracted-light study component 6, with a forward hexagon-like cross section maintained. Although the flux of light which has many include-angle components will carry out incidence to the diffracted-light study component 6 if it puts in another way, whenever [incident angle] is specified by the forward hexagon-head cone-like flux of light range. Therefore, as shown in drawing 4 (a), the flux of light which carried out incidence at the maximum include angle

corresponding to each ridgeline of the forward hexagon-head cone-like flux of light range the core [the image 47 (a drawing destructive line shows) of the shape of a ring which the flux of light which carried out vertical incidence to the diffracted-light study component 6 forms] will form the ring-like images 41-46 (a drawing solid line shows). The condition of having put the images 41-47 of the shape of a ring formed in the focal location of a lens 31 in this way on drawing 4 (b) is shown.
[0043] Since the flux of light of the number of infinity which has in fact the include-angle component of a large number specified by the forward hexagon-head cone-like flux of light range carries out incidence to the diffracted-light study component 6, the image of the shape of zona orbicularis as the image of the shape of a ring of the number of infinity put on the focal location of a lens 31 and shown in drawing 5 as a whole (in a circle) is formed. In addition, drawing 5 shows that the image put on the focal location of a lens 31 consists zona orbicularis-like of drawing 4 as a whole by the superposition of many ring-like images.
[0044] in addition -- the diffracted light -- study -- a component -- six -- the illumination light -- a way -- receiving -- insertion and detachment -- free -- constituting -- having -- and -- four -- a pole -- deformation -- lighting -- ** -- the diffracted light -- study -- a component -- 60 -- usually -- circular -- lighting -- ** -- the diffracted light -- study -- a component -- 61 -- a switch -- possible -- constituting -- having -- **** . About a configuration and an operation of the diffracted-light study component 60 for 4 pole deformation lighting and the diffracted-light study component 61 usually for circular lighting, it mentions later. Here, the switch between the diffracted-light study component 6 for zona-orbicularis deformation lighting, the diffracted-light study component 60 for 4 pole deformation lighting, and the diffracted-light study component 61 usually for circular lighting is performed by the 3rd drive system 24 which operates based on the command from a control system 21.
[0045] If drawing 1 is referred to again, incidence of the flux of light through the diffracted-light study component 6 will be carried out to a zoom lens 7. Here, a zoom lens 7 has the same operation as the lens 31 shown in drawing 3 . Moreover, near the backside [a zoom lens 7] focal plane, the plane of incidence of the fly eye lens 8 as an optical integrator is positioned. Therefore, every time it attracts the flux of light through the diffracted-light study component 6 to a backside [a zoom lens 7] focal plane, it forms a zona-orbicularis-like radiation field in it at the plane of incidence of the fly eye lens 8. The outer diameter of the radiation field of the shape of this zona orbicularis changes depending on the focal distance of a zoom lens 7. Thus, the zoom lens 7 is making substantially the diffracted-light study component 6 and plane of incidence of the fly eye lens 8 the relation of the Fourier transform. In addition, change of the focal distance of a zoom lens 7 is performed by the 4th drive system 25 which operates based on the command from a control system 21.
[0046] The fly eye lens 8 is constituted by arranging the lens element of a large number which have forward refractive power densely and in all directions. In addition, each lens element which constitutes the fly eye lens 8 has the cross section of the shape of a rectangle [**** / the configuration (as a result, configuration of the exposure field which should be formed on a wafer) of the radiation field which should be formed on a mask]. Moreover, the field by the side of the incidence of each lens element which constitutes the fly eye lens 8 is formed in the shape of [which turned the convex to the incidence side] the spherical surface, and the field by the side of injection is formed in the shape of [which turned the convex to the injection side] the spherical surface.
[0047] Therefore, the flux of light which carried out incidence to the fly eye lens 8 is divided by many lens elements two-dimensional, and a light source image is formed in a backside [each lens element in which the flux of light carried out incidence] focal plane, respectively. In this way, the a large number light source (henceforth the "secondary light source") of the shape of same zona orbicularis as the radiation field formed of the incoming beams to the fly eye lens 8 is formed in a backside [the fly eye lens 8] focal plane. Incidence of the flux of light from the secondary light source of the shape of zona orbicularis formed in the backside [the fly eye lens 8] focal plane is carried out to the aperture diaphragm 9 arranged in the near. This aperture diaphragm 9 is supported on the turret (rotor plate : drawing 1 un-illustrating) pivotable to the

circumference of a predetermined axis parallel to an optical axis AX.
[0048] Drawing 6 is drawing showing roughly the configuration of the turret by which two or more aperture diaphragms have been arranged in the shape of a periphery. As shown in drawing 6 , eight aperture diaphragms which have the light transmission region shown in the turret substrate 400 with the slash in drawing are prepared along with the circumferencial direction. The turret substrate 400 is constituted pivotable through the central point O at the circumference of an axis parallel to an optical axis AX. Therefore, one aperture diaphragm chosen from eight aperture diaphragms can be positioned all over an illumination-light way by rotating the turret substrate 400. In addition, rotation of the turret substrate 400 is performed by the 5th drive system 26 which operates based on the command from a control system 21.
[0049] Three zona-orbicularis aperture diaphragms 401, 403, and 405 from which a zona-orbicularis ratio differs are formed in the turret substrate 400. Here, the zona-orbicularis aperture diaphragm 401 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r11/r21. The zona-orbicularis aperture diaphragm 403 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r12/r22. The zona-orbicularis aperture diaphragm 405 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r13/r21.
[0050] Moreover, three 4 pole aperture diaphragms 402, 404, and 406 from which a zona-orbicularis ratio differs are formed in the turret substrate 400. Here, 4 pole aperture diaphragm 402 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r11/r21. 4 pole aperture diaphragm 404 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r12/r22. 4 pole aperture diaphragm 406 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r13/r21. Furthermore, two circular aperture diaphragms 407 and 408 from which magnitude (aperture) differs are formed in the turret substrate 400. Here, the circular aperture diaphragm 407 has the circular transparency field of the magnitude of two r22, and the circular aperture diaphragm 408 has the circular transparency field of the magnitude of two r21.
[0051] Therefore, by choosing zona-orbicularis 1 of three zona-orbicularis aperture diaphragms 401, 403, and 405, and positioning in an illumination-light way, the zona-orbicularis flux of light which has three different zona-orbicularis ratios can be restricted correctly (convention), and three kinds of zona-orbicularis deformation lighting with which zona-orbicularis ratios differ can be performed. Moreover, by choosing 4 pole 1 of three 4 pole aperture diaphragms 402, 404, and 406, and positioning in an illumination-light way, the four eccentric flux of lights which have three different zona-orbicularis ratios can be restricted correctly, and three kinds of 4 pole deformation lighting with which zona-orbicularis ratios differ can be performed. Furthermore, two kinds of usual circular lighting with which sigma values differ can be performed by choosing circular 1 of two circular aperture diaphragms 407 and 408, and positioning in an illumination-light way.
[0052] In drawing 1 , since the secondary zona-orbicularis-like light source is formed in a backside [the fly eye lens 8] focal plane, one zona-orbicularis aperture diaphragm chosen from three zona-orbicularis aperture diaphragms 401, 403, and 405 as an aperture diaphragm 9 is used. However, the class and number of aperture diaphragms which are instantiation-like [the configuration of a turret shown in drawing 6], and are arranged are not limited to this. Moreover, the possible aperture diaphragm of changing light transmission area size and a configuration suitably may be attached fixed in an illumination-light way, without being limited to the aperture diaphragm of a turret method. Furthermore, it can replace with two circular aperture diaphragms 407 and 408, and the tris diaphragm to which the diameter of circular opening can be changed continuously can also be prepared.
[0053] The light from the secondary light source through the aperture diaphragm 9 which has zona-orbicularis-like opening (light transmission section) carries out homogeneity lighting of the mask 11 with which the predetermined pattern was formed in superposition, after receiving a condensing operation of the capacitor optical system 10 as light guide optical system. The flux of light which penetrated the pattern of a mask 11 forms the image of a mask pattern through

projection optics 12 on the wafer 13 which is a photosensitive substrate. In this way, the pattern of a mask 11 is serially exposed by each exposure field of a wafer 13 by performing one-shot exposure or scanning exposure, carrying out drive control of the wafer 13 two-dimensional into the flat surface (XY flat surface) which intersects perpendicularly with the optical axis AX of projection optics 12.
[0054] In addition, in one-shot exposure, a mask pattern is exposed in package to each exposure field of a wafer according to the so-called step-and-repeat method. In this case, the configuration of the lighting field on a mask 11 has the shape of a rectangle near a square, and turns into the shape of a rectangle also with the cross-section configuration of each lens element of the fly eye lens 8 near a square. On the other hand, in scanning exposure, scanning exposure of the mask pattern is carried out to each exposure field of a wafer according to so-called step - and - scanning method, making a mask and a wafer displaced relatively to projection optics. In this case, the ratio of a shorter side and a long side has the shape of a rectangle of 1:3, and the configuration of the lighting field on a mask 11 turns into the shape of a rectangle [**** / the cross-section configuration of each lens element of the fly eye lens 8 / this].
[0055] Drawing 7 is drawing showing roughly the configuration from the micro-lens array 4 to the plane of incidence of the fly eye lens 8, and is drawing explaining the relation between the scale factor of the afocal zoom lens 5 and the focal distance of a zoom lens 7, and the magnitude of a zona-orbicularis-like radiation field and the configuration that are formed in the plane of incidence of the fly eye lens 8. In drawing 7 , the beam of light 70 which carried out incidence to the core of the micro lens arranged on the optical axis AX of the micro-lens array 4 in accordance with the optical axis AX is injected in accordance with an optical axis AX. As for the micro-lens array 4, the focal distance is constituted for size (dimension corresponding to the diameter of circle circumscribed to a forward hexagon) from the micro lens of f1 by a. After a beam of light 70 minds the afocal zoom lens 5, in accordance with an optical axis AX, incidence of it is carried out to the diffracted-light study component 6.
[0056] The diffracted-light study component 6 forms beam-of-light 70a injected at an include angle theta to an optical axis AX based on the beam of light 70 which carried out vertical incidence in accordance with the optical axis AX. Beam-of-light 70a injected at the include angle theta reaches the plane of incidence of the fly eye lens 8 through the zoom lens 7 of a focal distance f2 from the diffracted-light study component 6. At this time, the location of beam-of-light 70a in the plane of incidence of the fly eye lens 8 has the height of y from an optical axis AX. The beam of light 71 which carried out incidence to the optical axis AX on the other hand in the maximum rising wood of the micro lens arranged on the optical axis AX of the micro-lens array 4 at parallel is injected at an include angle t to an optical axis AX. After this beam of light 71 minds the afocal zoom lens 5 of a scale factor m, incidence of it is carried out to the diffracted-light study component 6 by include-angle t' to an optical axis AX.
[0057] The beam of light 71 which carried out incidence to the diffracted-light study component 6 by include-angle t' to the optical axis AX is changed into various beams of light containing beam-of-light 71a injected at an include angle (theta+t') to an optical axis AX. Beam-of-light 71a injected from the diffracted-light study component 6 at the include angle (theta+t') to the optical axis AX reaches the height of (y+b) from an optical axis AX in the plane of incidence of the fly eye lens 8 through a zoom lens 7. Furthermore, the beam of light 72 which carried out incidence to the optical axis AX at the lowest edge of the micro lens arranged on the optical axis AX of the micro-lens array 4 at parallel is injected at an include angle t to an optical axis AX. After this beam of light 72 minds the afocal zoom lens 5, incidence of it is carried out to the diffracted-light study component 6 by include-angle t' to an optical axis AX.
[0058] The beam of light 72 which carried out incidence to the diffracted-light study component 6 by include-angle t' to the optical axis AX is changed into various beams of light containing beam-of-light 72a (un-illustrating) injected at an include angle (theta-t') to an optical axis AX. Beam-of-light 72a injected from the diffracted-light study component 6 at the include angle (theta-t') to the optical axis AX reaches the height of (y-b) from an optical axis AX in the plane of incidence of the fly eye lens 8 through a zoom lens 7.

[0059] In this way, the range where the emission flux of light from each light source image formed near the backside [the micro-lens array 4] focal plane reaches the plane of incidence of the fly eye lens 8 turns into range which has width-of-face 2b focusing on the height of y from an optical axis AX. That is, as shown in drawing 7 (b), the radiation field of the shape of zona orbicularis formed in the plane of incidence of the fly eye lens 8, as a result the secondary light source of the shape of zona orbicularis formed in a backside [the fly eye lens 8] focal plane will have main height y from an optical axis AX, and will have width-of-face 2b.
[0060] Here, t' is expressed with the following formula (1) and (2) whenever [from the micro-lens array 4 / angle-of-emergence / t], and, whenever [to the diffracted-light study component 6 / incident angle].
t=a/(2, f1) (1)
t'=t/m=a/(2, f1, andm) (2)
Moreover, the zona-orbicularis-like main height y, the highest height (y+b), and the minimum height (y-b) of the secondary light source are expressed with following formula (3) - (5), respectively.
y=f2 and sintheta (3)
y+b=f2 (sintheta+sint') (4)
y-b=f2 (sintheta-sint') (5)
[0061] Therefore, bore phii of the secondary zona-orbicularis-like light source Outer-diameter phio The zona-orbicularis ratio A specified by the ratio is expressed with the following formula (6).
[Equation 1]
A=phi i/phio =2 (y-b)/(2 (y+b))
= sintheta-sint'/(sintheta+sint')
= sintheta-sin(a/(2, f1, andm))/(sintheta+sin(a/(2, f1, andm)) (6))
[0062] Moreover, outer-diameter phio of the secondary zona-orbicularis-like light source It is expressed with the following formula (7).
[Equation 2]
phio =2(y+b) =2, f2 (sintheta+sint')
= 2, f2 (sin theta+sin (a/(2, f1, andm))) (7)
[0063] In this way, it turns out that only the width-of-face 2b changes, without main height y of the secondary zona-orbicularis-like light source changing, if formula (2) - (6) is referred to, and the scale factor m of the afocal zoom lens 5 changes. That is, both the magnitude (outer-diameter phio) of the secondary zona-orbicularis-like light source and its configuration (zona-orbicularis ratio A) can be changed by changing the scale factor m of the afocal zoom lens 5.
[0064] Moreover, it turns out that both main height y and its width-of-face 2b change, without the zona-orbicularis ratio A of the secondary zona-orbicularis-like light source changing, if formula (3) - (7) is referred to, and the focal distance f2 of a zoom lens 7 changes. That is, it is outer-diameter phio by changing the focal distance f2 of a zoom lens 7, without changing the zona-orbicularis ratio A of the secondary zona-orbicularis-like light source. It can change. As mentioned above, it is outer-diameter phio of the secondary zona-orbicularis-like light source by changing suitably the scale factor m of the afocal zoom lens 5, and the focal distance f2 of a zoom lens 7. The zona-orbicularis ratio A can be changed without making it change.
[0065] Thus, when using the micro-lens array 4 and the diffracted-light study component 6 for zona-orbicularis deformation lighting, the secondary zona-orbicularis-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and zona-orbicularis deformation lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm 9 which, as a result, restricts the flux of light from the secondary light source good.
[0066] As mentioned above, to the illumination-light way, it is constituted free [insertion and detachment], and the micro-lens array 4 is constituted possible [the micro-lens array 40 for 4 pole deformation lighting and a switch]. moreover -- the diffracted light -- study -- a component -- six -- the illumination light -- a way -- receiving -- insertion and detachment -- free -- constituting -- having -- and -- four -- a pole -- deformation -- lighting -- ** -- the

diffracted light -- study -- a component -- 60 -- usually -- circular -- lighting -- ** -- the diffracted light -- study -- a component -- 61 -- a switch -- possible -- constituting -- having -- **** . While replacing with the micro-lens array 4 and setting up the micro-lens array 40 all over an illumination-light way hereafter, 4 pole deformation lighting obtained by replacing with the diffracted-light study component 6, and setting up the diffracted-light study component 60 all over an illumination-light way is explained.

[0067] The micro-lens array 40 consists of micro lenses 40 which have the forward refractive power of the shape of a square of a large number arranged densely and in all directions, as shown in drawing 1 and drawing 8 . Therefore, although many light source images are formed in a backside [the micro-lens array 40] focal plane, the flux of light from each light source image turns into the emission flux of light which has a square-like cross section, respectively, and carries out incidence to the afocal zoom lens 5. Incidence of the flux of light through the afocal zoom lens 5 is carried out to the diffracted-light study component 60 for 4 pole deformation lighting. The emission flux of light from each light source image formed in the backside [the micro-lens array 40] focal plane at this time is converged on the diffraction side of the diffracted-light study component 60, with a square-like cross section maintained.

[0068] The diffracted-light study component 60 for 4 pole deformation lighting changes the thin flux of light which carried out vertical incidence to the optical axis AX at parallel into the four flux of lights emitted to a radial according to the one predetermined angle of emergence, as shown in drawing 9 (a). If it puts in another way, the thin flux of light which carried out vertical incidence in accordance with the optical axis AX will be diffracted along four equiangular and specific directions centering on an optical axis AX, and will turn into the four thin flux of lights. Furthermore, the thin flux of light which carried out vertical incidence will be changed into the diffracted-light study component 60 at the four flux of lights, the square to which the shunt of the four flux of lights which pass through the field of back parallel to the diffracted-light study component 60 is connected will turn into a square, and the core of the square will exist in a detail on the incidence axis to the diffracted-light study component 60.

[0069] Therefore, if the thick parallel flux of light carries out vertical incidence to the diffracted-light study component 60 as shown in drawing 9 (b), four points (punctiform light source image) 92 will be too formed in the focal location of the lens 91 arranged behind the diffracted-light study component 60. Here, if the thick parallel flux of light which carries out incidence to the diffracted-light study component 60 is leaned to an optical axis AX as shown in drawing 9 (c), four images formed in the focal location of a lens 91 will move. That is, if the thick parallel flux of light which carries out incidence to the diffracted-light study component 60 inclines along a predetermined field, four points 93 formed in the focal location of a lens 91 will move to the sense opposite to the sense to which the flux of light inclines along a predetermined field.

[0070] As mentioned above, the emission flux of light from each light source image formed in the backside [the micro-lens array 40] focal plane is converged on the diffraction side of the diffracted-light study component 60, with a square-like cross section maintained. Although the flux of light which has many include-angle components will carry out incidence to the diffracted-light study component 60 if it puts in another way, whenever [incident angle] is specified by the forward square cone-like flux of light range. That is, since the flux of light of the number of infinity which has the include-angle component of a large number specified by the forward square cone-like flux of light range carries out incidence to the diffracted-light study component 60, the image of the shape of 4 poles as the point of the number of infinity put on the focal location of a lens 91 and shown in drawing 10 as a whole is formed. Therefore, every time it attracts the flux of light through the diffracted-light study component 60 to a backside [a zoom lens 7] focal plane, it forms a 4 pole-like radiation field in it at the plane of incidence of the fly eye lens 8. Consequently, as shown in drawing 11 , the secondary light source of the shape of same 4 poles as the radiation field formed in plane of incidence is formed also in a backside [the fly eye lens 8] focal plane.

[0071] In addition, corresponding to the switch to the micro-lens array 40 from the micro-lens array 4, and the switch for the diffracted-light study component 60 from the diffracted-light study component 6, the switch to aperture-diaphragm 9a from the zona-orbicularis aperture

diaphragm 9 is performed. Aperture-diaphragm 9a is one 4 pole aperture diaphragm chosen from three 4 pole aperture diaphragms 402, 404, and 406. Thus, also when using the micro-lens array 40 and the diffracted-light study component 60 for 4 pole deformation lighting, the secondary 4 pole-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and 4 pole deformation lighting can be performed, suppressing the quantity of light loss in aperture-diaphragm 9a which, as a result, restricts the flux of light from the secondary light source good.
[0072] In addition, as shown in drawing 11 , 4 pole-like the magnitude and the configuration of the secondary light source can be similarly defined as the secondary zona-orbicularis-like light source. In this case, the size a of each micro lens which constitutes the micro-lens array 40 is defined as a dimension corresponding to the diameter of circle circumscribed to the square which is that cross-section configuration. In this way, it is outer-diameter phio of the secondary 4 pole-like light source by changing the scale factor m of the afocal zoom lens 5 like the case of zona-orbicularis deformation lighting. And both the zona-orbicularis ratios A can be changed. Moreover, it is outer-diameter phio by changing the focal distance f2 of a zoom lens 7, without changing the zona-orbicularis ratio A of the secondary 4 pole-like light source. It can change. Consequently, it is outer-diameter phio of the secondary 4 pole-like light source by changing suitably the scale factor m of the afocal zoom lens 5, and the focal distance f2 of a zoom lens 7. The zona-orbicularis ratio A can be changed without making it change.
[0073] Subsequently, while evacuating both the micro-lens arrays 4 and 40 from an illumination-light way, the usual circular lighting obtained by replacing with the diffracted-light study components 6 or 60, and setting up the diffracted-light study component 61 for circular lighting all over an illumination-light way is explained. In this case, the flux of light which has a rectangle-like cross section in accordance with an optical axis AX carries out incidence to the afocal zoom lens 5. It is expanded or reduced according to the scale factor, and the flux of light which carried out incidence to the afocal zoom lens 5 is injected from the afocal zoom lens 5 in accordance with an optical axis AX with the flux of light which has a rectangle-like cross section, and carries out incidence to the diffracted-light study component 61.
[0074] Here, the diffracted-light study component 61 for circular lighting has the function to change into the flux of light of a circle configuration the flux of light of the shape of a rectangle which carried out incidence. Therefore, the circular flux of light formed of the diffracted-light study component 61 forms the radiation field of the circle configuration centering on an optical axis AX in the plane of incidence of the fly eye lens 8 through a zoom lens 7. Consequently, the secondary light source of the circle configuration centering on an optical axis AX is formed also in a backside [the fly eye lens 8] focal plane. In this case, the outer diameter of the secondary light source of a circle configuration can be suitably changed by changing the focal distance f2 of a zoom lens 7.
[0075] In addition, corresponding to evacuation from the illumination-light way of the micro-lens arrays 4 and 40, and a setup on the illumination-light way of the diffracted-light study component 61 for circular lighting, the switch to circular aperture-diaphragm 9b from the zona-orbicularis aperture diaphragm 9 or 4 pole aperture-diaphragm 9a is performed. Circular aperture-diaphragm 9b is one circular aperture diaphragm chosen from two circular aperture diaphragms 407 and 408, and has opening of the magnitude corresponding to the secondary light source of a circle configuration. Thus, by evacuating the cone prism 4 from an illumination-light way, the secondary light source of a circle configuration is formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and circular lighting can usually be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the flux of light from the secondary light source good.
[0076] Hereafter, switch actuation of the lighting in this example etc. is explained concretely. First, the information about various kinds of masks which should carry out sequential exposure according to step-and-repeat method or step - and - scanning method etc. is inputted into a control system 21 through the input means 20, such as a keyboard. The control system 21 has memorized information, such as optimal line breadth (resolution) about various kinds of masks, and the depth of focus, in the internal memory section, answers an input from the input means

20, and supplies the suitable control signal for the 1st drive system 22 – the 5th drive system 26.
[0077] That is, when carrying out zona-orbicularis deformation lighting under the optimal resolution and the depth of focus, the 1st drive system 22 positions the micro-lens array 4 of zona-orbicularis deformation lighting all over an illumination-light way based on the command from a control system 21. Moreover, the 3rd drive system 24 positions the diffracted-light study component 6 for zona-orbicularis deformation lighting all over an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the shape of zona orbicularis which has desired magnitude (outer diameter) and a desired zona-orbicularis ratio in a backside [the fly eye lens 8] focal plane, the 2nd drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, and the 4th drive system 25 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary zona-orbicularis-like light source, the 5th drive system 26 rotates a turret based on the command from a control system 21, and positions a desired zona-orbicularis aperture diaphragm all over an illumination-light way. In this way, the secondary zona-orbicularis-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and zona-orbicularis deformation lighting can be performed, without almost carrying out quantity of light loss in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.
[0078] Furthermore, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source which are formed in a backside [the fly eye lens 8] focal plane can be suitably changed if needed by changing the scale factor of the afocal zoom lens 5 by the 2nd drive system 23, or changing the focal distance of a zoom lens 7 by the 4th drive system 25. In this case, a turret rotates according to change of the magnitude of the secondary zona-orbicularis-like light source, and a zona-orbicularis ratio, the zona-orbicularis aperture diaphragm which has desired magnitude and a desired zona-orbicularis ratio is chosen, and it is positioned all over an illumination-light way. In this way, without almost carrying out quantity of light loss in formation and its limit of the shape of zona orbicularis of the secondary light source, zona-orbicularis-like the magnitude and the zona-orbicularis ratio of the secondary light source can be changed suitably, and various zona-orbicularis deformation lighting can be performed.
[0079] Moreover, when carrying out 4 pole deformation lighting under the optimal resolution and the depth of focus, the 1st drive system 22 positions the micro-lens array 40 for 4 pole deformation lighting all over an illumination-light way based on the command from a control system 21. Moreover, the 3rd drive system 24 positions the diffracted-light study component 60 for 4 pole deformation lighting all over an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the shape of 4 poles which has desired magnitude (outer diameter) and a desired configuration (zona-orbicularis ratio) in a backside [the fly eye lens 8] focal plane, the 2nd drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, and the 4th drive system 25 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary 4 pole-like light source, the 5th drive system 26 rotates a turret based on the command from a control system 21, and positions desired 4 pole aperture diaphragm all over an illumination-light way. In this way, the secondary 4 pole-like light source can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and 4 pole deformation lighting can be performed, suppressing quantity of light loss good in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.
[0080] Furthermore, 4 pole-like the magnitude and the configuration of the secondary light source which are formed in a backside [the fly eye lens 8] focal plane can be suitably changed if needed by changing the scale factor of the afocal zoom lens 5 by the 2nd drive system 23, or changing the focal distance of a zoom lens 7 by the 4th drive system 25. In this case, a turret rotates according to change of the magnitude of the secondary 4 pole-like light source, and a configuration, 4 pole aperture diaphragm which has desired magnitude and a desired configuration

is chosen, and it is positioned all over an illumination-light way. In this way, where quantity of light loss is suppressed good in formation and its limit of the shape of 4 poles of the secondary light source, 4 pole-like the magnitude and the configuration of the secondary light source can be changed suitably, and various 4 pole deformation lighting can be performed.
[0081] Furthermore, when carrying out the circular lighting usual by the basis of the optimal resolution and the depth of focus, the 1st drive system 22 evacuates the micro-lens arrays 4 and 40 from an illumination-light way based on the command from a control system 21. Moreover, the 3rd drive system 24 usually positions the diffracted-light study component 61 for circular lighting all over an illumination-light way based on the command from a control system 21. And in order to acquire the secondary light source of the circle configuration which has desired magnitude (outer diameter) in a backside [the fly eye lens 8] focal plane, the 2nd drive system 23 sets up the scale factor of the afocal zoom lens 5 based on the command from a control system 21, and the 4th drive system 25 sets up the focal distance of a zoom lens 7 based on the command from a control system 21. Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary light source of a circle configuration, the 5th drive system 26 rotates a turret based on the command from a control system 21, and positions a desired circular aperture diaphragm all over an illumination-light way. In addition, in using the tris diaphragm to which the diameter of circular opening can be changed continuously, the 5th drive system 26 sets up the diameter of opening of a tris diaphragm based on the command from a control system 21. In this way, the secondary light source of a circle configuration can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and circular lighting can usually be performed, suppressing quantity of light loss good in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.
[0082] Furthermore, the magnitude of the secondary light source of the circle configuration formed in a backside [the fly eye lens 8] focal plane can be suitably changed if needed by changing the focal distance of a zoom lens 7 by the 4th drive system 25. In this case, a turret rotates according to change of the magnitude of the secondary light source of a circle configuration, the circular aperture diaphragm which has opening of desired magnitude is chosen, and it is positioned all over an illumination-light way. In this way, suppressing quantity of light loss good in formation and its limit of the shape of a square of the secondary light source, a sigma value can be changed suitably and various usual circular lighting can be performed.
[0083] As mentioned above, in the above-mentioned example, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of deformation lighting or usual circular lighting can be changed by easy actuation of changing the scale factor of an afocal zoom lens, or changing the focal distance of a zoom lens, suppressing the quantity of light loss by the aperture diaphragm good. Therefore, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions.
[0084] Since the wafer which passed through the process (photolithography process) of exposure by the aligner of an above-mentioned example should pass the process to develop, a wafer process ends it through the process of resist removal of removing the unnecessary resist after the process of etching of removing parts other than the developed resist, and the process of etching etc. And finally termination of a wafer process manufactures the semiconductor devices (LSI etc.) as a device like an actual erector through each process, such as dicing which was able to be burned and which cuts and chip-izes a wafer for every circuit, bonding which gives wiring etc. to each chip, and packaging which carries out packaging for every chip.
[0085] In addition, although the above explanation showed the example which manufactures a semiconductor device according to the photolithography process in the wafer process which used the projection aligner, a liquid crystal display component, the thin film magnetic head, and

image sensors (CCD etc.) can be manufactured as a device according to the photolithography process using an aligner. In this way, since projection exposure can be performed under good exposure conditions in the case of the exposure approach of manufacturing a device using the illumination-light study equipment of this invention, a good device can be manufactured.
[0086] In addition, in an above-mentioned example, it can constitute so that the diffracted-light study component as the micro-lens array and flux of light sensing element as an emission flux of light formation component may be positioned all over an illumination-light way for example, by the turret method. Moreover, insertion and detachment and a change of an above-mentioned micro-lens array and a diffracted-light study component can also be performed, for example using a well-known slider style.
[0087] Moreover, in the above-mentioned example, the configuration of the micro lens which constitutes the micro-lens array for zona-orbicularis deformation lighting is set as a forward hexagon. This is because cannot arrange densely but quantity of light loss occurs, so the forward hexagon is selected as a circularly near polygon in the micro lens of a circle configuration. However, the configuration of each micro lens which constitutes the micro-lens array for zona-orbicularis deformation lighting can use other suitable configurations, without being limited to this. Although similarly the configuration of the micro lens which constitutes the micro-lens array for 4 pole deformation lighting is set as a square, other suitable configurations which include the shape of a rectangle, for example can be used. Moreover, although refractive power of the micro lens which constitutes a micro-lens array is made into forward refractive power in the above-mentioned example, the refractive power of this micro lens may be negative.
[0088] Furthermore, although the afocal zoom lens is used in the above-mentioned example, the configuration which arranges the diffracted-light study component for replacing with an afocal zoom lens and changing the rectangle-like flux of light into the circular flux of light ahead of a micro-lens array using a focal zoom lens is also possible. Moreover, in the above-mentioned example, although one fly eye lens is used, this invention is applicable also to the double fly eye method using two fly eye lenses.
[0089] Furthermore, although the diffracted-light study component 61 is positioned all over an illumination-light way in the above-mentioned example in case the usual circular lighting is performed, use of this diffracted-light study component 61 is also omissible.
[0090] Moreover, in the above-mentioned example, although the micro-lens array is used as an emission flux of light formation component, a fly eye lens, a diffracted-light study component, etc. can also be used if needed. Furthermore, in the above-mentioned example, although the diffracted-light study component is used as a flux of light sensing element, a dioptrics component like a micro-lens array or micro-lens prism can also be used, for example, without being limited to this. By the way, the detailed explanation about the diffracted-light study component which can be used by this invention is indicated by the U.S. Pat. No. 5,850,300 official report etc.
[0091] Furthermore, in the above-mentioned example, the aperture diaphragm for restricting the flux of light of the secondary light source is arranged near the backside [a fly eye lens] focal plane. However, the configuration which omits arrangement of an aperture diaphragm and does not restrict the flux of light of the secondary light source at all is also possible by setting up sufficiently small the cross section of each lens element which constitutes a fly eye lens depending on the case. Moreover, although the above-mentioned example explained this invention taking the case of the projection aligner equipped with illumination-light study equipment, it is clear that this invention is applicable to the common illumination-light study equipment for carrying out homogeneity lighting of the irradiated planes other than a mask.
[0092] In addition, in an above-mentioned operation gestalt, although considered as the configuration which condenses the light from the secondary light source formed in the location of an aperture diaphragm 9 with the condensing lens 10 as light guide optical system, and illuminates a mask 11 in superposition, the relay optical system which forms the image of an illuminated viewing field diaphragm (mask blind) and this illuminated viewing field diaphragm on a mask 11 between a condensing lens 10 and a mask 11 may be arranged. In this case, light guide optical system consists of a condensing lens 10 and relay optical system, a condensing lens 10

will condense the light from the secondary light source formed in the location of an aperture diaphragm 9, an illuminated viewing field diaphragm will be illuminated in superposition, and relay optical system will form the image of opening of an illuminated viewing field diaphragm on a mask 11.

[0093] Moreover, what is necessary is for the optical system by the side of a mask 11 just to consist of zoom lenses 7 as the 2nd optical system as follows in an above-mentioned operation gestalt, in using the rod mold integrator of an internal reflection mold as an optical integrator although the fly eye lens 8 which is a wavefront-splitting mold integrator as an optical integrator was used. That is, condensing optical system is added to the downstream of a zoom lens 7, and the conjugation side of the diffracted-light study component 6 as a flux of light sensing element is formed. And a rod mold integrator is arranged so that an incidence edge may be positioned near [this] the conjugation side. And the relay optical system which forms the image of the illuminated viewing field diaphragm arranged near the injection end face of this rod mold integrator or the injection end face on a mask 11 is arranged. In this configuration, the 2nd predetermined side turns into a pupil surface of the synthetic system of a zoom lens 7 and the above-mentioned condensing optical system, and the secondary light source is formed in the pupil surface of relay optical system (the virtual image of the secondary light source is formed near the incidence edge of a rod mold integrator). In this case, the relay optical system for leading the flux of light from a rod mold integrator to a mask turns into light guide optical system.

[0094] moreover, as optical intensity distribution which become strong in the periphery section which is weakly separated from a criteria optical axis with an above-mentioned operation gestalt in a field including a criteria optical axis, or the field near the criteria optical axis Optical intensity distribution to which optical reinforcement becomes strong in the field of the shape of zona orbicularis which surrounds the optical axis of illumination-light study equipment on a predetermined side (the shape of a doughnut) (zona-orbicularis-like distribution), Although considered as the intensity distribution (4 pole-like distribution) to which reinforcement becomes strong in two or more four fields substantially arranged by the equiangular distance around the optical axis of illumination-light study equipment on a predetermined side Optical intensity distribution (for example, when it is eight places: 8 pole-like distribution) to which reinforcement becomes strong in two or more four or more fields substantially arranged by the equiangular distance around the optical axis of illumination-light study equipment on a predetermined side are sufficient. Although the above-mentioned example shows the example which forms the secondary 4 pole-like light source if it puts in another way, the secondary 2 pole (the 2nd)-like light source or the secondary light source of the shape of a multipole like the shape of 8 poles (the 8th) can also be formed, for example.

[0095] Moreover, in the above-mentioned operation gestalt, although two or more element lenses are accumulated and the fly eye lens 8 is formed, it is also possible to make these into a micro lens array. With a micro lens array, two or more very small lens sides are established in a light transmission nature substrate in the shape of a matrix by technique, such as etching. Although there is no difference in a function between a fly eye lens and a micro lens array substantially about the point which forms two or more light source images, it is points, like that magnitude of opening of one element lens (very small lens) can be made very small, that a manufacturing cost is sharply reducible, and thickness of the direction of an optical axis can be made very thin, and a micro lens array is advantageous.

[0096] Now, in this example, since wavelength, such as KrF excimer laser (wavelength: 248nm) and ArF excimer laser (wavelength: 193nm), uses exposure light 180nm or more as the light source, a diffracted-light study component can be formed with quartz glass. in addition, in using the wavelength of 200nm or less as an exposure light The quartz glass with which the quartz glass with which the fluorite and the fluorine were doped, a fluorine, and hydrogen were doped in the diffracted-light study component, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose OH radical concentration is 1000 ppm or more, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose hydrogen content child concentration is three or more 1x1017 molecules/cm, Whenever

[structure decision constant temperature] or less by 1200K And the quartz glass whose level of chlorine is 50 ppm or less, And it is desirable to form with the ingredient chosen from the group of the quartz glass whenever [whose / structure decision constant temperature] are 1200K or less and, whose hydrogen content child concentration is three or more 1x1017 molecules/cm and, and whose level of chlorine is 50 ppm or less.

[0097] in addition, about the quartz glass whenever [whose / structure decision constant temperature] are 1200K or less and whose OH radical concentration is 1000 ppm or more It is indicated by the patent No. 2770224 official report by the applicant for this patent. Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose hydrogen content child concentration is three or more 1x1017 molecules/cm, Whenever [structure decision constant temperature] or less by 1200K And the quartz glass whose level of chlorine is 50 ppm or less, And whenever [structure decision constant temperature] is indicated by the 1200 according to applicant for this patent about quartz glass whose hydrogen content child concentration are K or less and is three or more 1x1017 molecules/cm and whose level of chlorine is 50 ppm or less patent No. 2936138 official report.

[0098]

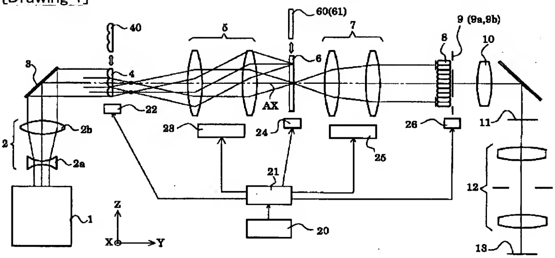
[Effect of the Invention] As explained above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of deformation lighting can be changed by easy actuation of changing the scale factor of an afocal zoom lens, or changing the focal distance of a zoom lens, suppressing the quantity of light loss by the aperture diaphragm good.

[0099] Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure approach which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good device can be manufactured.

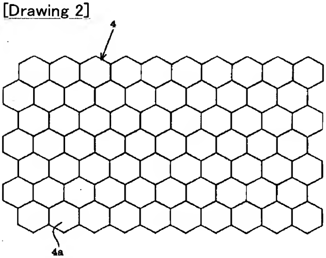
[Translation done.]

DRAWINGS

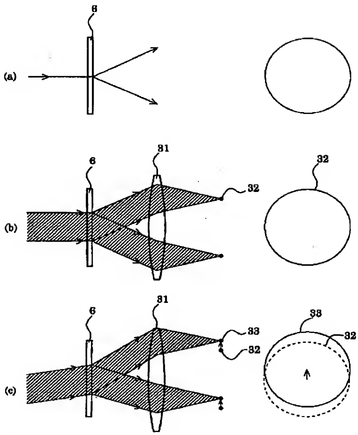
[Drawing 1]



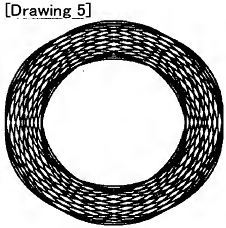
[Drawing 2]



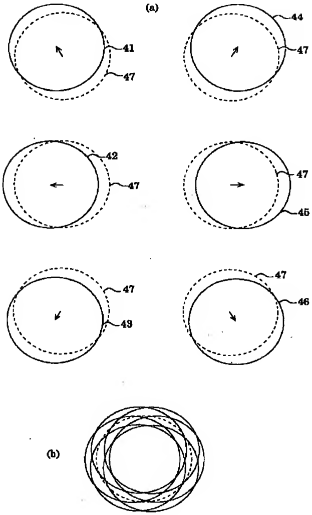
[Drawing 3]



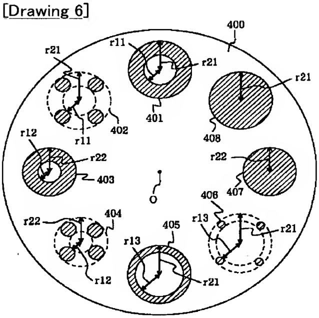
[Drawing 5]



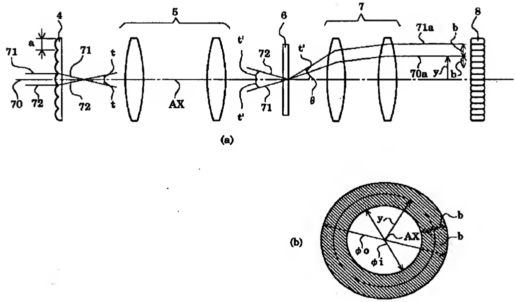
[Drawing 4]



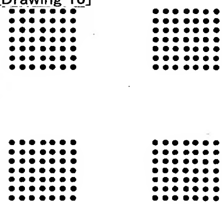
[Drawing 6]



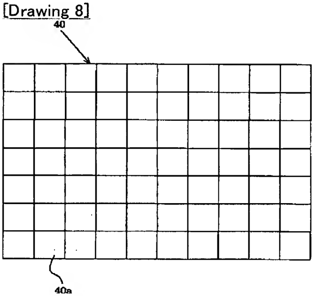
[Drawing 7]



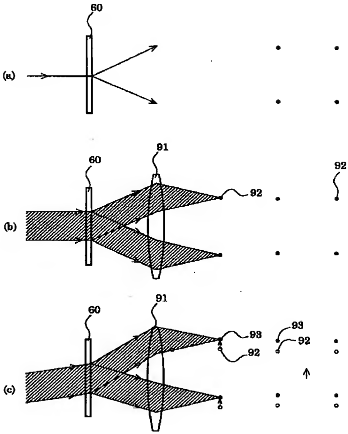
[Drawing 10]



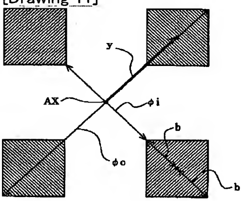
[Drawing 8]



[Drawing 9]



[Drawing 11]



[Translation done.]